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EUNIS brings together those who are responsible for the management, development and the policy for Information Technology in Higher Education in Europe. The objective of EUNIS is to contribute to the development of high quality information systems. To achieve this, the aims of EUNIS are:

- encourage exchange, cooperation and debates between those responsible for information systems in higher education or research institutes/organizations within Europe;
- establish relationships with supervisory organizations in charge of information systems in higher education and in research institutes in each country as well as at European level.

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The "Zentrum für Informationsverarbeitung" (ZIV) is the service and competence centre of Münster University for IT-infrastructure, for communication and media technology, and for the transfer of media competence. The ZIV performs both centralised and decentralised services, including planning, installation, operating and support as well as service and maintenance. Furthermore, it supports activities on a decentralised level which refer to the whole communication network, the telecommunication system, audio-visual media, computers, system software and application software.

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OPENX AND INTEROPERABILITY

NEW IDEAS AND INNOVATIVE CONCEPTS

Future challenges for quality-assured IT support through cooperative structures

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1. ABSTRACT

In the future, various new challenges will arise in quality-assured IT support at universities. University computing center are increasingly being encouraged to provide IT services not only for their own universities but for other universities and research institutes as well. Additionally, cooperation between various university IT service providers is essential. The joint service of different service providers of a university for additional external facilities leads to the need to adapt existing support structures in order to continue to guarantee the best possible quality of service. In the following these new challenges will be examined using the example of the IT Center at RWTH Aachen University within the context of transformation of support structures.

2. MOTIVATION

The IT Center of RWTH Aachen University is one of the central IT service providers at the university (apart from the central university administration (ZHV) and the university library (UB)). The service catalogue of the IT Center includes the provision of approximately 50 basic and individual services to students, staff, and the facilities of the university, as well as external cooperation partners. These services include identity management, e-mail, telephone, data network, backup, managed services for institutes and the CAMPUS information system.

In order to better meet customer needs and requirements IT Service Management (ITSM) was introduced in 2008 according to the IT Infrastructure Library (ITIL). This is a de facto standard that define IT Service Management through good practice guidelines and incorporates it organizationally.

Objectives of ITSM at the IT Center of RWTH Aachen University:

- The IT Center is to be perceived as a reliable partner for all user groups.
- The IT Center is an interdisciplinary partner.
- The IT Center strengthens its customer orientation.
- The processes at the IT Center are optimized and there is an increase in transparency and liability towards the users (Bischof, Hengstebeck & Grzemski, 2011).

As part of the establishment of ITSM the IT-ServiceDesk was opened in 2010 as the central point of contact for all inquiries regarding the IT services of the IT Center. It is responsible for responding to defined inquiries as well as for coordinating the communication between users and specialist division involved in more complex queries.

Through the establishment of the IT-ServiceDesk as a ‘Single Point of Contact’, it was possible to meet the users’ request for high-quality IT support. In order to highlight and maintain a high support quality the IT-ServiceDesk was successfully certified according to the DIN ISO 9001:2015 standard in 2016 (Pieters, Hengstebeck & Grzemski, 2017). This certification confirms that a quality management system has been operated successfully and developed further.

The current 1st- and 2nd-level support structures are focused on service provision for members of RWTH Aachen University.

Due to emerging changes (Deutsche Forschungsgemeinschaft, 2016; Wissenschaftsrat, 2015a) in the academic landscape in North Rhine-Westphalia (NRW) and all of Germany, different services – for example HPC (high-performance computing) – will be consolidated. Because of this, the IT Center is striving for more closely knit collaborations with the ZHV and the UB of RWTH Aachen University. This will promote a strong common representation and positioning in the country. The goal is to act as a reliable collaboration partner both within RWTH Aachen University and with other interested research institutions. Already established support structures and services must be adapted and further developed according to these new requirements.

The focus of this article lies in the adaptation of support structures within the context of partnership with ZHV and UB as well as external research institutions. Besides some implications regarding financial aspects and challenges are addressed only marginally because these are not the focus of this paper.

3. DEMAND FOR MORE COOPERATIONS

The development and operation of IT services is becoming increasingly complex. In order to operate and develop an IT service with a defined quality of service ample resources are needed (in addition to the relevant technology, personnel with the appropriate qualifications). At the present time, a large number of university computer centers operate all necessary services themselves. Ultimately, this has a negative effect on the quality and availability of the respective services since the necessary resources can often not be provided with the required quality.

It stands to reason to focus competencies on a few specific services and offer them with an excellent quality instead of trying to provide all services and only being able to do so with lesser quality. Services that as a result can no longer be operated by a university are then obtained from other organizations that have focused their expertise on these. In this way the individual university computer centers form centers of competence for specific services and make use of services offered by others. Focusing on specific services thus builds a high level of know-how of the operation and further development of these services.

Not only have the computing centers themselves recognized that it is neither effective nor efficient to operate all services themselves. The Commission for IT Infrastructure (KfR) of the Deutsche Forschungsgemeinschaft (DFG) recommends a sustainable IT strategy in the opinion piece ´Informationsverarbeitung an Hochschulen – Organisation, Dienste und Systeme´ (Deutsche Forschungsgemeinschaft, 2016) and states that required IT services do not necessarily have to be supported by the local computer center but can also be obtained from external service providers:

´Die interne Optimierung von Prozessen, Organisationsstrukturen und inhaltlicher Ausrichtung der Hochschulen […] führt typischerweise zu hochschulspezifischen Lösungen beim effizienten Einsatz von IT. Dieser Prozess kann jedoch nicht an den Grenzen einer Hochschule aufhören.´ (Deutsche Forschungsgemeinschaft, 2016)

In addition to the Deutsche Forschungsgemeinschaft (DFG), also states in its 'Empfehlungen zur Finanzierung des Nationalen Hoch- und Höchstleistungsrechnens in Deutschland' (Wissenschaftsrat, 2015a) that cooperative structures must be created. Moreover, future high-performance computers will also be available for nationwide use. This will result in an increase of the user groups which requires the support from the universities running a computing cluster.

These requirements are taken into account by RWTH Aachen University in their IT concept (RWTH Aachen, 2016). It is noted that the university or the three central IT service providers will be working as service providers for other universities and research institutes.

Such collaborations have already existed rudimentarily for some time. For example the University of Paderborn has been using RWTH IT Center's backup and archive service for several years. The IT Center also runs the Exchange infrastructure at the University of Paderborn.

In a pilot project the IT Center provides the central Exchange infrastructure for the employees of the universities of the Fine Arts at the Essen location.

In this model the external institution acts as a 1st-level support entity for their users, sometimes there are also external specialist division which act as 2nd-level. Accordingly, the IT-ServiceDesk or the IT Center (specialist division) then becomes the 2nd or 3rd-level support unit. The orange arrows shows the escalation leves the queries can take. The green arrows describe answering paths. To point to the blue arrows, they describe how the communication and hence the answers are forwarded from the local to the external institution or external users. A particular variation shows the green arrow that illustrat that the specialist division IT Center comunicat to the external specialist division. For technical reasons this procedure may be helpful.

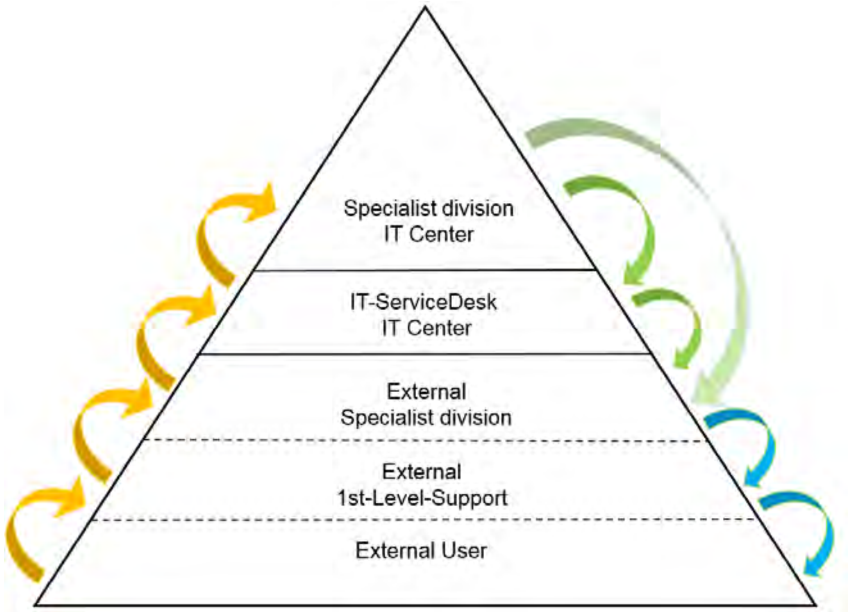

Illustration 1: Support pyramid: Exchange

In cases where the IT Center receives services from other universities or research institutions the support structure is as follows. A successful example of this kind of partnership is the service Sciebo of the University of Münster (Sync & Share NRW, 2017).

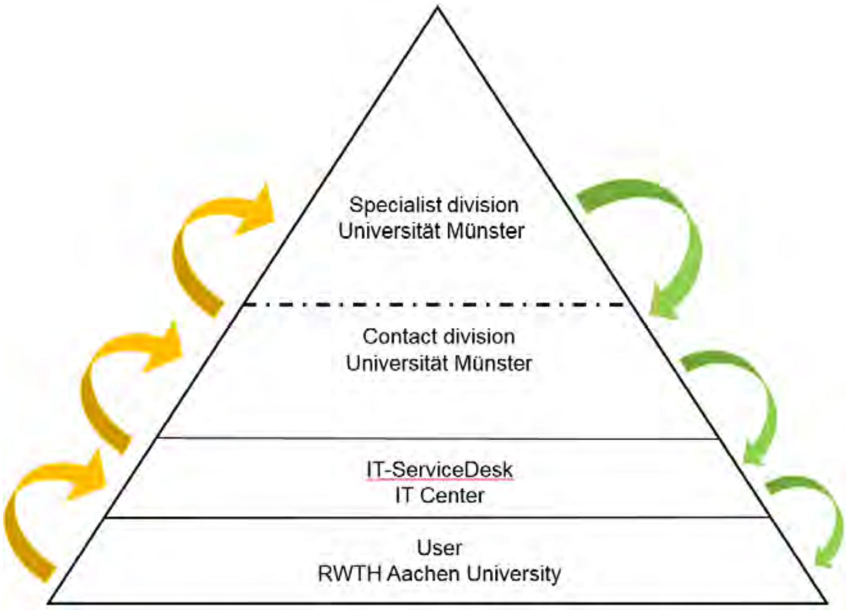

Illustration 2: Support pyramid: Sciebo

Here, the local computing center (IT Center) offers its users the Sync and Share service 'Sciebo' which is provided and further developed by the University of Münster. This service can be used by all members of RWTH Aachen University. The 1st-level support for members of RWTH Aachen University is provided by the IT-ServiceDesk of the IT Center. Inquiries which go beyond the defined 1st-level support are forwarded to the 2nd-level Sciebo-support. The replies by the 2nd-level support will be passed on to the users by the 1st-level support of the IT Center.

4. FUTURE SUPPORT STRUCTURES

The new collaborative orientations of the computing centers imply that the support structures introduced so far have to be transformed in order to be able to continue providing high-quality support. Within this context, it is important not only to take into account the fact that external institutions of higher education and research may use services, but also that different services within the university may be provided by different institutions and/or external partners. For example, at RWTH Aachen University, the new Campus Management system was conceived jointly by all institutions involved in the university (faculties, ZHV, UB and the IT Center) and launched together with the implementing external partner.
Another example is the research data management (Wissenschaftsrat, 2015b) which is required by a new legal framework. This is provided jointly by the UB, the Research and Career Department, as well as the IT Center of RWTH Aachen University.
Noteworthy is a cooperation with the Forschungszentrum Jülich where the Eduroam device management system is being designed.

These three examples are presented below in regard to their challenges for the support structures.

4.1. New scenarios in IT support

As already described, it is necessary to transform the existing support structures in order to ensure high-quality and customer-oriented support in light of new requirements. In the following, new support scenarios are described using three short case studies.

1. **Interdisciplinary service for coordinating and organizing student lifecycle and teaching (example Campus Management System)**

   Within the context of the establishment of a new Campus Management System (RWTH Aachen PuL-Projekt, 2017) for the organization of the student lifecycle and teaching the existing support structures must also be adapted to accommodate the large number of institutions involved (Student Office, Central Examination Office, IT Center, Departmental Student Adviser etc.). Until now, users had to address their queries directly to one of the above-mentioned institutions but it was not always clear which institution could answer the question. As a result, they were often referred from one institution to another. In order to avoid this in the future, all queries relating to the new campus management system are to be directed to one central address. All participating institutions can access these requests, for example via a common ticket tool. The challenge here is introducing the ticket tool to all institutions that have not used it so far. They may be skeptical and lacking expertise in using it.

2. **Interdisciplinary service for the scientific community (example: research data management)**

   These services are provided not only by the local computing center but also in cooperation with other institutions of a university. At RWTH Aachen University, for example, the research data management is collaboratively provided by UB, the Research and Career Department and the IT Center (RWTH Aachen Forschungsdatenmanagement, 2017). The IT-ServiceDesk serves as a single point of contact for all inquiries regarding research data management. Accordingly the IT-ServiceDesk is responsible for answering defined standard requests. More sophisticated inquiries are forwarded to the appropriate institution. Currently, users are receiving a solution from the responsible institution at RWTH Aachen University directly, rather than via the IT-ServiceDesk.

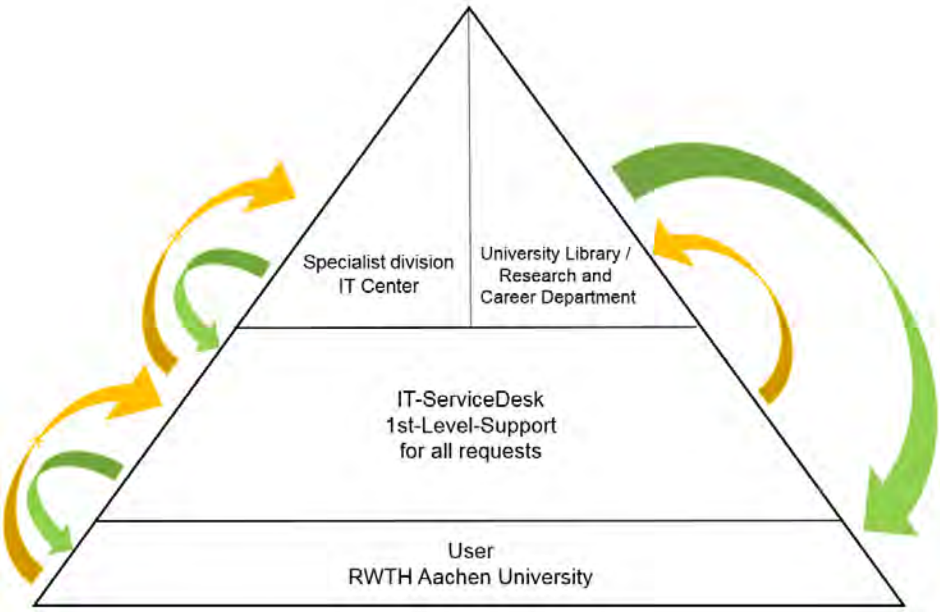

Illustration 3: Support pyramid structure: research data management

3. **Joint conceptualization and development of a service between two mutually independent institutions (example: Eduroam Device Management)**

   The local computing center and an external research-oriented partner organization are designing and developing a service (both technically and organizationally). This is then provided and operated by the local computing center. Further development of the service would happen in collaboration with the other institution. If the service was to be offered to additional institutions they might become involved in the further development as well.

   One example is the Eduroam Device Management which was developed by the IT Center and Forschungszentrum Jülich. This is an application to create and manage device-specific Eduroam identifiers. Before the introduction of this application, users often chose the same password for their Wi-Fi/VPN account and other RWTH accounts. The new Eduroam Device Management generates individual Wi-Fi credentials for each device (Decker, Politze, 2017).

This increases the security of other RWTH service accounts because they would not be affected if Eduroam access data were compromised by a identity theft. Furthermore, existing Eduroam login credentials can be deactivated individually and immediately if a device is lost.

The idea for the Eduroam Device Management was developed at the IT Center. It also carried out a first implementation for the members of RWTH Aachen University. In discussions with Forschungszentrum Jülich, the research center expressed its own need for such an application. To ensure that it would not have to invest its own resources in the development of such a system, the service was collaboratively developed. Now, other external institutions could use this service as well. The service and thus the support concept are currently still under development but probably it will be guided by illustration 4.

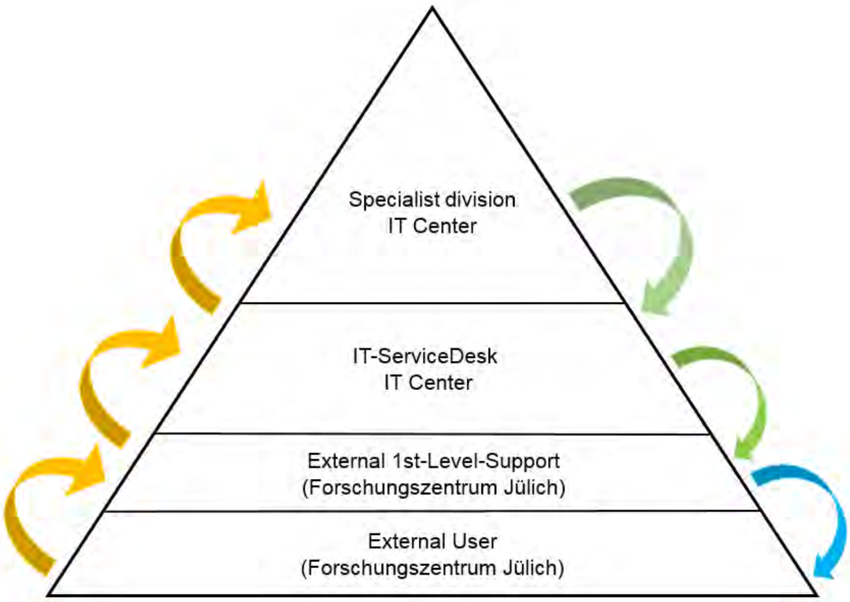

Illustration 4: Support pyramid Eduroam Device Management

4.2. Challenges of the new support scenarios

The aforementioned scenarios present several new challenges to the 1st-level support. These can be classified as follows:

1. Formal challenges
2. Work organization and communicative challenges
3. Technical challenges

Formal challenges:

For all three scenarios it is necessary to establish in addition to default servicelevel agreements (SLAs) service description and special support agreements between the participating institutions in which the following points are taken into account.

The agreements must indicate at which institution which level of support is located or whether a division of support will take place. For example it would be possible that the 1st-level support is located at the utilizing institution and only requests which go beyond previously defined 1st-level support are passed on to the providing institution. In this case it would become necessary to define precise limits between the 1st and 2nd level support.

In general, it must be determined whether support requests which are passed on to the university providing services are billed individually or whether they are charged at a flat rate. If billing was defined according to the number of requests a reliable and transparent reporting would have to be put into place for accurate billing. Furthermore reporting is also required for documentation and quality assurance.

In addition to the precise definition of support responsibilities it is necessary to define contact persons. It should be noted who is entitled to make inquiries to the service provider. It is also important to determine the ways in which requests are exchanged between the institutions and how they are documented. The use of a ticket system is a particularly big challenge here.

To ensure that all requests are processed in a timely manner, appropriate escalation times and procedures must be negotiated between the participating institutions.

Further formal challenges is the consideration of data protection. Especially when full support is provided by the service provider, it might be necessary to access users' personal data in order to guarantee high-quality support. The responsible data protection officers are to be involved here and it needs to be clarified whether and which data can be used and provided for the support.

At the organizational level it is necessary that quality management or quality assurance is incorporated. This can be ensured through regular exchange and review deadlines as well as coordinated reporting. If quality management and assurance processes already exist it is essential to expand these accordingly. In the context of quality management it must also be ensured that maintenance (for example deployment of hotfixes and patches) and changes are communicated at an early stage. Essentially for updates it is necessary to create a release management and fixed release plans which are coordinated in advance. The one-time negotiation of the support framework conditions is not useful as a review and adjustment must take place at regular intervals in order to ensure a high quality.

Organizational and communicative challenges

In addition to the formal challenges, work organization and communication challenges arise. For example, it must be taken into account that there is an increased workload for support staff since now not only the local users make inquiries but also users or defined contact persons from other institutions. In this case, the staff has to know or understand who is eligible for support from the external facility. This can only be achieved by keeping the process documentation up-to-date. Furthermore it is absolutely necessary to design a model oriented training program for the local and also the external institution.

It must also be agreed how the support documentation is maintained – whether a central documentation platform for all participating institutions or individual documentation for each institution is kept.

In addition to the documentation, marketing must also be coordinated. The following questions need to be clarified:

1. Is there any central marketing by the service provider?
2. Through which channels will the service be advertised?
3. Are marketing documents provided centrally?
4. Is a corporate design required for the service?

Furthermore participating institutions may have different support times. These times might, for example, be restricted by internal organizational factors (such as events, meetings, etc.). Such restrictions must be appropriately communicated and discussed ahead of time and might be part of support agreements.

The greatest communication challenge, however, is to highlight the benefits of such collaborative services to staff and users. It must be clear to everyone involved that rather than taking something away from someone, a high quality of IT services can only be achieved by close collaboration. It is therefore necessary to create a common understanding for the importance of working together.

Technical challenges

The technical challenges can be divided into two themes. Technical solutions must be created that allow interactions between the participating institutions to be exchanged without media breaks. Only in this way a high quality of support and its documentation is possible. The experience with the service 'Sciebo' has shown that it is not ideal to forward support requests from the 1st-level support via emails sent through the ticket tool to the 2nd-level support as this causes media breaks.

Due to the use of two different ticket tools in the local 1st-level support and the external 2nd-level support incidences occurred in which a second inquiry from the 1st-level support to the 2nd-level ticket system could no longer be assigned to the original request. This happened because the 1st-level support ticket system removed the ticket number of the 2nd-level ticket system from the subject of the email. So far no automated technical solution could be implemented to fix this. As a result only a manual workaround is possible:

If the 2nd-level support answers a request by email the latter must include the ticket number of the ticket system in the email text. When the 1st-level support responds to this request the ticket number from the email text must be entered into the subject of the email to the 2nd-level support. This is currently the best available way for the 2nd level support to track the history of a request.

This example shows that the exchange of inquiries between two institutions can be quite challenging. Due to the large number of different ticket systems it is necessary to clarify in advance whether a smooth interaction between them is possible. If this is not the case it becomes necessary to provide appropriate technical solutions. Generally, the usage of as limited a number of different tools as possible should be sought.

In addition to the described technical interaction, administration and monitoring tools must be provided for the 1st-level support depending on the specific nature of the support. In the case of the Sciebo service an administrative interface is provided to the 1st-level support units of the participating institutions through which simple activities, e.g. the creation of project boxes can be carried out. To simplify authorization management this interface is linked to the identity management of the participating institutions.

For the service Eduroam Device Management which is operated by the IT Center of RWTH Aachen University and will be made available to other institutions in addition to Forschungszentrum Jülich, administration and monitoring tools will be provided for every 1st level division of these institutions.

5. CONCLUSION AND OUTLOOK

Due to the service provision for external institutions as well as for collaboratively provided services within the university the existing support structures have to be adapted under formal, organizational and technical aspects. Organizationally the existing processes must be modified in such a way that the external users are also taken into account and clear responsibilities are defined. At the IT Center and the IT-ServiceDesk lots of innovations regarding the ´formal challenges´ have already been implemented internally e.g. support agreements. This means that support agreements between the IT-ServiceDesk and the specialist division have been drawn up and are being reviewed at regular intervals by the quality management of the IT-ServiceDesk. In other computer centers that also work in a process-oriented manner similar processes or procedures should exist. Extending these processes to external customers requires only minor adjustments to the processes and, if necessary, professionalization.

The adjustments in the field of billing become more complex if support requests are billed individually. In this case it is necessary to develop corresponding billing models that take into account how the 1st-level support and the 2nd-level support of the service provider is calculated. The development of a transparent billing model by the IT-ServiceDesk is ongoing. So far, transforming the support structures has been prioritized.

Regarding technical aspects, the necessary adjustments also have to be taken into account (among others) because appropriate administration and monitoring tools must be provided for each service that is to be provided externally. These have to be linked with the identity management of the utilizing institution. It should be borne in mind that not only tools for support are provided but also for the users' self-service applications.

The IT-ServiceDesk of the IT Center at RWTH Aachen University addresses the challenges described above. However, in order to face the challenges laid out in this article in the best way possible close cooperation between all participating institutions is crucial. Only through intensive communication between all parties involved can a transparent and quality-assured support with a high service quality for users be ensured.

In addition to the cooperation with the external institutions the IT-ServiceDesk also needs support from the specialist departments within the IT Center to implement technical solutions for the support itself as well as for the services.

Thanks to the work done so far by the IT-ServiceDesk it has been able to meet these challenges and develop itself further in order to support cooperative and collaborating IT services. However, this is associated with major changes that cannot be implemented quickly but must be introduced step by step in order to keep the burden on all parties involved low.

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DABAR - the national infrastructure for digital repositories

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digital repositories, institutional repositories, DABAR, digital asset management, DAM, data curation, open access, interoperability, electronic theses and dissertations, ETDS, Islandora

1. ABSTRACT

Having recognized the need for a national digital asset management infrastructure, SRCE – University of Zagreb University Computing Centre in association with a number of research and higher education institutions in Croatia built a national repository system called DABAR – Digital academic archives and repositories. DABAR provides research and higher education institutions with the common infrastructure necessary to establish a secure, reliable and interoperable institutional repositories in a simple way. Dabar allows institutions to manage their digital assets without the need to deal with technical issues related to the implementation and maintenance of digital repositories.

Until the middle of March 2017, DABAR was used to build two national repositories and 109 repositories of Croatian research and higher education institutions. Currently, it supports curation of electronic theses and dissertations, and papers published in electronic journals. The support for conference papers, book chapters, artistic works (photographs and other audio-visual objects) is being actively developed and a plan to build a support for managing research data sets and educational resources is in place.

The DABAR platform and the community gathered around it are actively promoting Open Access to the results of research and to educational modules and resources.

2. DIGITAL ASSETS MANAGEMENT AND OPEN ACCESS IN RESEARCH AND HIGHER EDUCATION COMMUNITY IN CROATIA

One of the first milestones in promotion and fostering of open access in Croatia was the announcement of the Portal of Croatian scientific journals, HRČAK, in February, 2006. Nowadays, HRČAK hosts more than 420 Croatian journals that publish full text articles in open access. The first time that "the principle of the openness to the public" in Croatia appeared in an official document was in 2006 in the *Science & Technology Policy of the Republic of Croatia* ("Znanstvena i tehnologijska politika Republike Hrvatske 2006. – 2010. godine", 2006). The document stipulated that the research and development results that had been funded by public funds had to be publicly available in open publications or open access databases. A couple of years later, in 2012, *The Croatian Open Access Declaration* was announced and signed by numerous institutions and individuals in Croatia. At that time, only a few institutions had a technical solution for archiving digital assets mainly based on EPrints software. The awareness about the need for the systematic approach to data curation in Croatia was still developing. The first digital repositories in Croatia were HRČAK, FAMENA PhD Collection, FOI digital library, University of Zagreb Medical School Repository, Faculty of Humanities and Social Sciences Institutional Repository and Full-text Institutional Repository of the Ruđer Bošković Institute FULIR. ("OA i OER u Hrvatskoj", 2013)

The importance of Open Access that brought together the scholarly community in Croatia was finally stated in *The Scientific Activity and Higher Education Act* ("Zakon o znanstvenoj djelatnosti i visokom obrazovanju", 2013), which requires universities and higher education institutions to permanently publish theses and doctoral dissertations in public databases (repositories).

Having recognized the Croatian academic and research community's need and aiming to enable it to fulfil its legal obligation, during 2014 SRCE initiated a network of numerous experts and scientists that were interested in digital repositories or had already been working on archiving digital assets for their institutions. Furthermore, SRCE established contact with numerous research and higher education institutions such as the National and University Library in Zagreb, the Ruđer Bošković Institute as well as other higher education and research institute libraries.

As individual institutional solutions for archiving and curation of digital assets were organizationally, financially and technically challenging, SRCE recognized the importance and advantages of building a national e-infrastructure for digital repositories. The vision of a national solution was welcomed not only by institutions that were under a legal obligation to establish digital repositories, but also by other institutions that saw the opportunity to collect and preserve their digital assets in one place.

In addition to the technical challenges in establishing digital repositories, research and higher education institutions were faced with organizational challenges in adopting internal policies and documents that entitle them not only to publish digital material created by their students and staff, but also to publish it according to the principles of open access.

On 4 March 2016, SRCE signed the memorandum of understanding with four institutions within the Croatian academic and research community: the Ruđer Bošković Institute, University of Zagreb School of Medicine, University of Zagreb Faculty of Humanities and Social Sciences and the National and University Library in Zagreb. The institutions agreed to foster organisational, informational and technical development of the national e-infrastructure for digital repositories – DABAR.

3. GOALS OF THE PROJECT

The main goal of the DABAR project was to build a robust and scalable national infrastructure for digital repositories that would enable research and higher education institutions to establish their own reliable and interoperable digital repositories. At the same time, this national infrastructure was expected to promote and follow open access principles.

Furthermore, each institution had to be able to build an institutional digital repository on the institution's internet domain. This was important especially to universities because the metrics that compare universities (e.g. Webometrics[1]) are based on the volume and quality of electronic publications available within universities' internet domain.

The technical requirements for DABAR were to provide a service that is:

- secure and reliable for long term preservation
- interoperable with other national and global infrastructures (e.g. Portal of Scientific Journals of Croatia, OpenAIRE, …)
- scalable (ability to support many institutions and large number and size of digital objects)
- sustainable
- flexible in the sense that it could be customized according to a particular institution's needs.

SRCE, as a major computing centre and the architect of the e-infrastructure for research and higher education community in Croatia, has taken responsibility for the development and maintenance of the necessary infrastructure, which includes: providing the networked computing resources and data storage, taking care of the security and reliability of the whole system and maintaining an application solution linked with appropriate middleware (national identity federation AAI@EduHr).

[1] http://www.webometrics.info/en/Methodology

From the very beginning, SRCE's plans included bringing together the wider community[2] to take an active role in shaping the services. Following tasks were planned:

- setting up working groups from the professional community, primarily advanced users of the system, which would take over the responsibility for:
    - the definition of the information needs of the community
    - the design and maintenance of common metadata profiles and controlled vocabularies
    - participation in education and support for the end users
- raising awareness about the importance of systematic preservation of research and higher education institutions' digital assets
- promotion of open access to research results and educational content.

At the same time, SRCE has aimed to establish its own sustainable and competent team for development, maintenance and continuous improvement of DABAR's services.

4. STATE OF THE DEVELOPMENT AND RESULTS OF THE PROJECT

As a result of the project, a service called DABAR[3] has been developed and released. DABAR is a part of the national infrastructure that enables a simple and free-of-charge set-up of a digital repository for all the institutions in the research and higher education community in Croatia. More information about the architecture and technical aspects of DABAR is provided in section 5.

DABAR's production started on 17 August 2015, and, by 17 March 2017, 109 digital repositories have been requested and set-up in the system. The amount of applications for the set-up of the repository is an indicator that the institutions have recognized the need for systematic management of their digital assets and DABAR as a solution to that need.

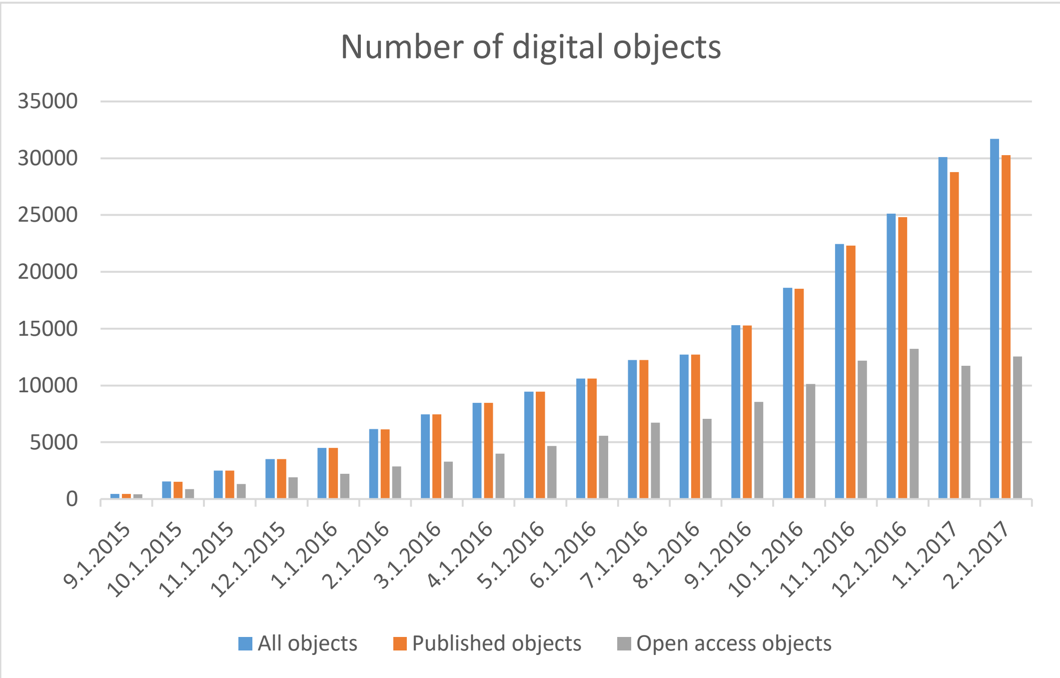

Figure 1. Number of digital objects stored in repositories in DABAR

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[2] https://dabar.srce.hr/en/partner-institutions

[3] https://dabar.srce.hr/en

SRCE has been periodically organising educational workshops for repository administrators. By 10 March 2017, a total of 14 workshops with 181 participants were held.

The National and University Library in Zagreb, in collaboration with SRCE and other higher education libraries, has defined metadata descriptions for digital objects “student thesis” and “dissertation and scientific master's thesis”. Those definitions were accepted at the national level, which ensures a high degree of interoperability and compliance with international standards. The metadata description for object “paper published in journal” along with needed controlled vocabularies were also defined and agreed upon at the national level.

By 1 March 2017, 30,276 digital objects were stored and described with rich metadata in repositories in DABAR. Figure 1. shows the number of digital objects stored in the repositories in DABAR by months (DABAR statistics, 2017).

In addition to the institutional repositories, through cooperation with the National and University Library in Zagreb, SRCE has set-up two national repositories:

- Croatian Digital Theses Repository at https://zir.nsk.hr
- Croatian Digital Dissertations Repository at https://dr.nsk.hr.

The impact of DABAR is recognized and visible at the national level through strong interest and involvement of research and higher education institutions (National and University Library, universities, colleges, libraries, institutes) resulting in a significant increase in the number of institutions that have decided to establish and maintain their digital repositories. Furthermore, the importance of publication of information in open access has gained momentum. On March 1st, the repositories in DABAR contained 11,744 digital objects available in open access.

During 2016, employees and students of institutions were involved in the process of storing digital objects through the implementation of self-archiving functionality. Eight Croatian universities have set-up their institutional repositories in DABAR. The team that worked on DABAR put a lot of effort in interoperability of DABAR with other repositories and services using the two basic technologies: REST API and OAI PMH.

5. ARHITECTURE OF DABAR’S INFRASTRUCTURE

DABAR’s repository system is based on Islandora[4], an open-source software framework. Islandora is designed to manage and discover digital assets and it has grown to be a reliable system for repository management. Main framework components are Fedora Commons, Apache SOLR and Drupal. Fedora Commons is another open-source project dealing with preserving and managing digital objects while offering exposure of stored resources through RESTful API. The framework uses well-known Apache SOLR for indexing Fedora content for faster metadata access using advanced and optimised search mechanisms. GSearch, as a part of the Fedora package, is used as a bridge for automatic synchronization between SOLR and Fedora content. Drupal is an open-source CMS providing Islandora users front-end for viewing, editing and storing digital objects in Fedora. Islandora’s built-in flexibility allows institutions to build large systems that can scale on demand and its modular architecture can be easily used for extending in desired directions.

DABAR ensures constant development and expansion while meeting a demanding functionality roadmap. Research and higher education institutions, repository managers and end users expected rich and accurate metadata and, at the same time, efficiency in storing and describing digital objects. To meet those expectations, it was necessary to rely on existing infrastructures and data sources (Figure 2). One of the first tasks while building DABAR was to enable user authentication through Croatian science and higher education identity federation AAI@EduHr[5] so that the users could use their existing institutional credentials and single sign-on functionality.

The support for depositing electronic theses in repositories in DABAR relies on Information System of Higher Education Institutions (ISVU). ISVU is a national information system which had been, by the

[4] https://islandora.ca/about

[5] http://www.aaiedu.hr/en

end of February 2017, used by 111 Croatian higher education institutions to administer data on teachers, assistants, syllabi, curricula, students enrollments, exams, tuitions, theses etc. In addition, ISVU exposes data through well-documented REST API. In the process of describing and storing theses in repositories, the metadata are fetched from ISVU. Other national registries (for example the Registry of study programs maintained by the Ministry of Science and Education) are used in the process of storing theses and dissertations. The fact that these sources were used for depositing digital objects in repositories and that metadata will be publicly available, *motivated and encouraged* institutions and the Ministry to increase the data quality and accuracy.

While building support for describing and storing papers published in journals to institutional repositories, the development team acknowledged the fact that there were already repositories in which these objects might be described and stored. The HRČAK[6] portal is a platform built for Croatian journal editors for publishing journals in Open Access. On 14 March 2017, it contained more than 155,000 papers available in full text which were described and stored by journal editors of more than 420 journals. To retrieve article metadata and URL of files in PDF format, DABAR uses HRČAK's OAI-PMH[7] interface. For the articles that have a DOI assigned by CrossRef, DABAR uses CrossRef API[8] to retrieve article metadata which was delivered to CrossRef in the process of assigning a DOI to the article. Similar connection is being built for retrieving metadata and PDF's from Croatian Scientific Bibliography (CROSBI) which stores scientific papers with more than 460,000 bibliographic records and more than 30,000 full-text papers available (Hrvatska znanstvena bibliografija, 2017). The plan is to implement metadata retrieval from PubMed Central. PubMed Central is a free full-text archive of biomedical and life sciences journal literature which exposes articles metadata through API[9].

A unique persistent identifier URN:NBN is assigned to each digital object stored in any repository in DABAR. The URN:NBN is assigned by URN:NBN service developed and maintained by the National and University Library in Zagreb.

Besides support for direct input via user interface, digital object can be stored in repositories in DABAR via the DABAR REST API. DABAR REST API was implemented because there were various external sources that already contained the fully described digital objects and had the need to transfer and store the objects in a repository in DABAR. One example of a system that is using DABAR REST API is institutional information system that already has theses stored but doesn't have all the dissemination features of a full-blown digital repository. Another use-case for DABAR REST API is an existing stand alone institutional repository that wants to migrate its content to the repository in DABAR.

An important role of digital repositories is to support dissemination. Besides the user interface, all repositories in DABAR have a built-in OAI-PMH which exposes structured metadata in two standard metadata formats: Dublin Core (DC)[10] and Metadata Object Description Schema (MODS)[11]. All OAI-PMH interfaces of repositories in DABAR are fully compliant with the OpenAIRE Guidelines for Literature Repository Managers 3.0[12] and are ready to be registered as a data provider on the OpenAIRE portal.

The landing pages of the digital objects all have Highwire Press and Dublin Core <meta> tags recommended by Google Scholar Inclusion guidelines for Webmasters[13]. This ensures that digital objects will be included in Google Scholar searches.

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[6] http://hrcak.srce.hr

[7] https://www.openarchives.org/pmh/

[8] https://github.com/Crossref/rest-api-doc/blob/master/rest_api.md

[9] https://www.ncbi.nlm.nih.gov/home/develop/api.shtml

[10] http://dublincore.org/documents/dces/

[11] http://www.loc.gov/standards/mods/

[12] https://guidelines.openaire.eu/en/latest/literature/index.html

[13] https://scholar.google.com/intl/en/scholar/inclusion.html#indexing

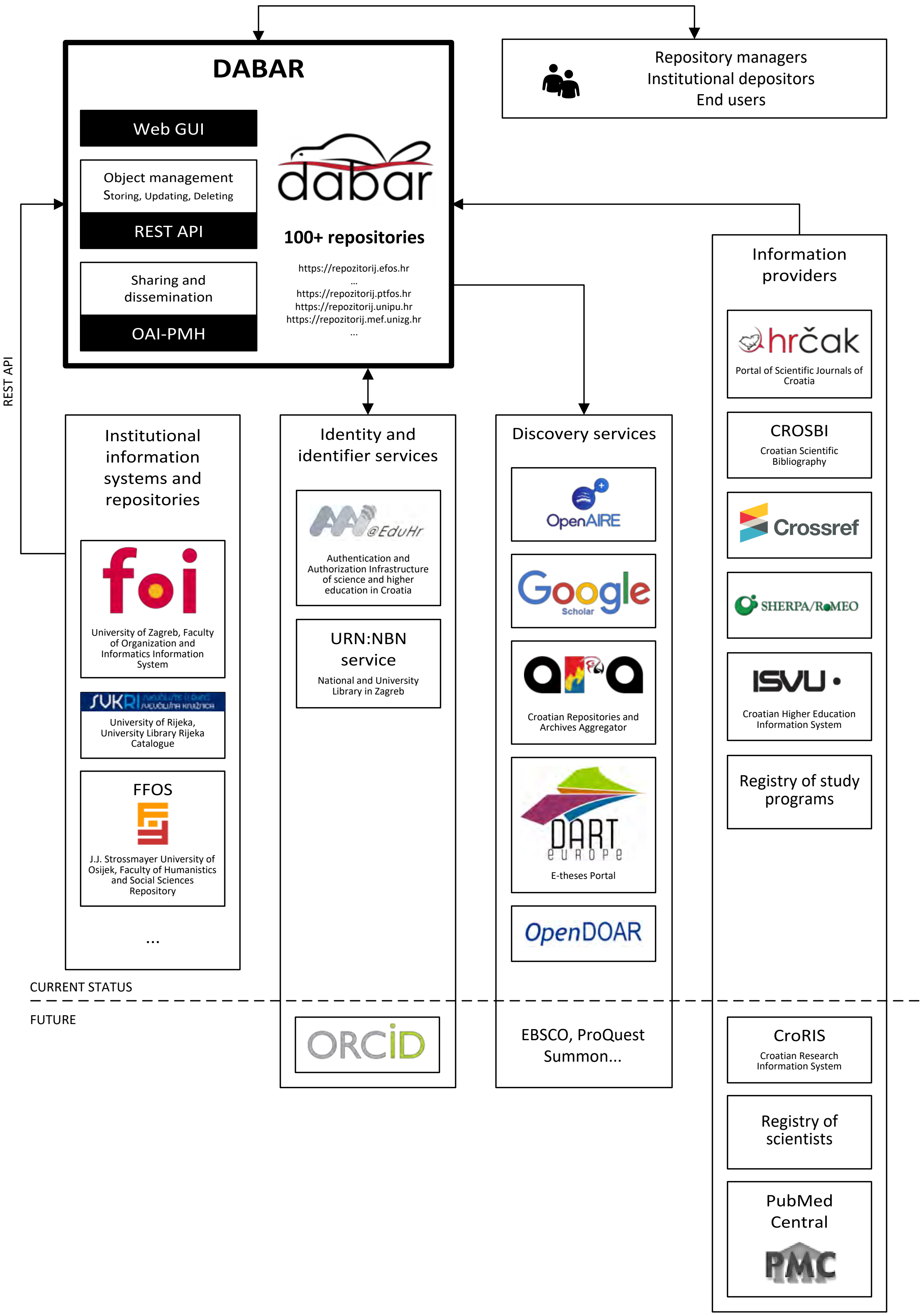

Figure 2. DABAR's integration with national and global e-infrastructure

DABAR's presence on OpenAIRE portal, Google Scholar and other discovery services drives a greater number of readers to repositories and its content and makes the repository content, authors and institutions more visible. Figure 2 ilustrates DABAR's integration with other national and global services.

DABAR's modular architecture is presented in Figure 3. Each of the servers has its unique function in the Islandora framework, extended with continuous integration (CI) server and servers that are mirroring production environment for development purposes. DABAR was built following Software as a Service (SaaS) delivery model in order to provide easy access to a fully featured platform for the institutions which are using it.

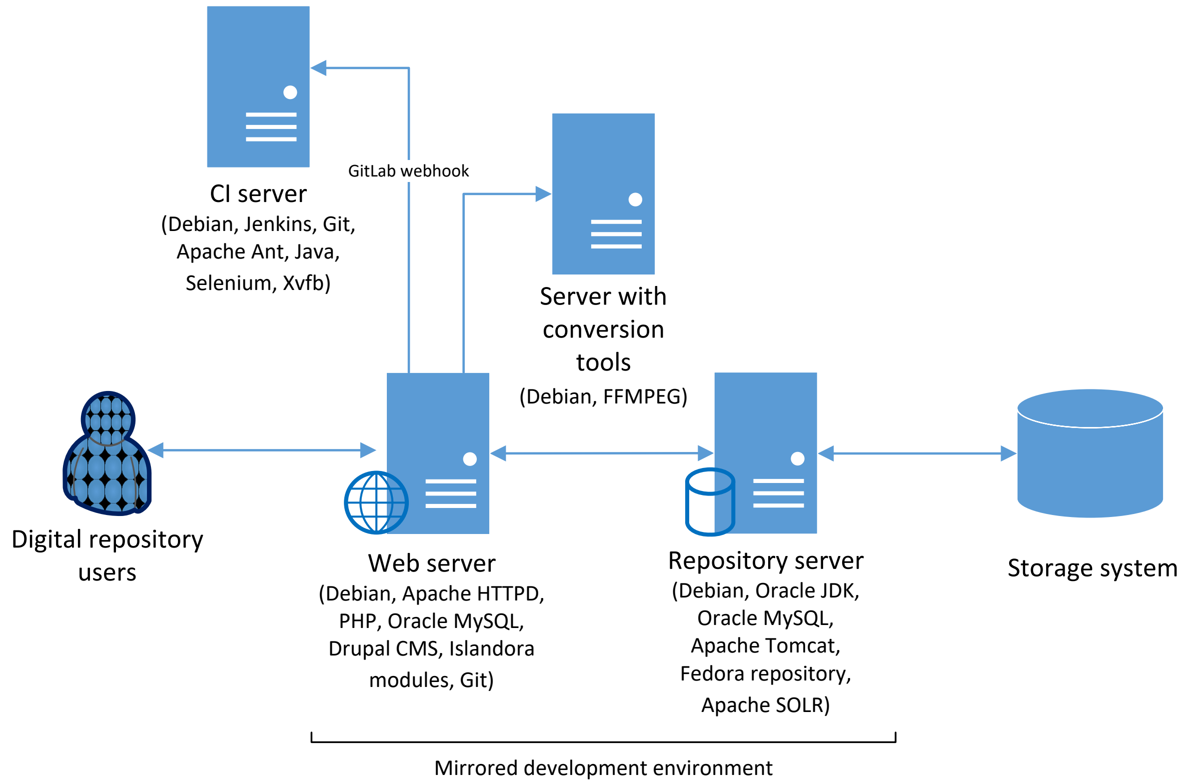

Figure 3. DABAR architecture

6. FURTHER DEVELOPMENTS

DABAR has brought together the research and higher education community providing them with a nationally accepted solution for preservation and dissemination of electronic theses and dissertations, articles published in scientific and professional journals. Still, that is just a good start in fulfilling the institutional needs. Next digital objects that will be introduced during 2017 are conference papers and presentations, book chapters, books and artistic works, including photographs and audio-visual objects. In 2017 we plan to start the work on research data management and educational content.

Given that only 40,8% (11,744 from 28,779) of all available objects in repositories in DABAR are published in open access, a big challenge for DABAR team and community is to promote open access further and support institutions in creating preconditions for publishing in open access.

Interoperability, in particular with national information systems in science and higher education stays in our focus.

7. CONCLUSION

109 digital repositories were established in DABAR's repository system by research and higher education institutions in Croatia. This proves that DABAR has been recognised as a reliable, secure and easy-to-use national infrastructure for the set-up and maintenance of interoperable and sustainable digital repositories. The model of centrally managed national infrastructure helps in reducing the costs of development and maintenance. It provides interoperability for all of its repositories with national and global e-infrastructures. This model is applicable outside the system of science and higher education, for example, in elementary and secondary education system as a repository of educational content or as a commercial platform for hosting digital repositories. It is also applicable in other countries or as an international solution that would meet the need of a specific community.

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Introducing the Learning Scorecard: a tool to improve the student learning experience

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Keywords
Student learning; Balanced Scorecard; Business Intelligence; Gamification.

1. SUMMARY

Improving the student learning experience is an essential aspect of teaching. This paper presents the Learning Scorecard (LS), a tool designed to monitor and manage the learning experience of students in a course. The LS has a student view and a faculty (or course coordinator) view. The student view essentially focuses on time management and uses gamification to engage students with the course's activities. In the faculty view, data is aggregated from the student's view, enabling the course coordinator to monitor the average progress of students in the different classes of the course he/she is lecturing. The Learning Scorecard has been developed using Business Intelligence and performance management techniques. It includes a Balanced Scorecard and dashboards for the visualization and monitoring of the student learning experience. In this paper the design of the LS will be presented as well as some initial results with an ongoing experiment in a course lectured in different Higher Education programs within the same university.

2. THE LEARNING SCORECARD

The Learning Scorecard is a performance management tool that applies the quality management principle of *"if you can't measure it, you can't manage it and improve it"*. The goal of the LS is to provide Higher Education students with an analytical environment enabling the monitoring of their performance in a course, contributing to the enhancement of the student learning experience. By measuring the individual student learning performance, the LS also enables the course coordinator to monitor the ongoing learning experience of students throughout the semester. Given its context, the LS is a case study of learning analytics, a recent research area, focusing on the measurement and analysis of "data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs," (Long and Siemens, 2011).

This project started in the spring semester of the 2015-2016 academic year, as a research project of a group of graduate students of a course on Decision Support Systems at the University Institute of Lisbon (ISCTE-IUL), a public university in Lisbon, Portugal. It is currently the research theme of two master dissertations in Computer Science Engineering. The LS has already been used to improve the learning experience of students in the Data Warehouse course, in the winter semester of 2016-2017 (Cardoso et al., 2016). Presently, the LS tool is being tested in the Business Intelligence course, lectured in undergraduate and graduate programs – an ongoing experiment that will be concluded in May 2017.

The Learning Scorecard design includes a balanced scorecard (with a strategy map and a quantification framework) and a set of dashboards for the monitoring of the student learning experience. Since the LS is designed for two "customer segments" – students and course coordinator – which have different goals, expectations and pain points, the tool provides two separate views: the student view and the faculty view. The strategy map, in Figure 1, describes the most important strategic objectives and their dependencies (called cause-and-effect relationships) in order to achieve the strategy of a course (which basically consists of achieving the learning outcomes with an improved student learning experience). In this map, there are three perspectives: Students and Faculty, Internal Processes, and Learning and Growth. The financial perspective, the fourth standard perspective in a Balanced Scorecard is not relevant for the Learning Scorecard, which is focused solely on the student learning experience. At the right end side of Figure 1, are the values that drive this strategic project, which are defined from a student's view as: pursue growth and learning, enjoying participation and self-discipline. The strategy map is draw as a "mobile phone", as a metaphor for the portability of the LS platform. One of the design requirements of the LS relates to the portability across web browsers (Firefox, Google Chrome, Safari, Edge) including mobile devices. The development of a mobile application for the student view is also contemplated in the near future.

The strategy map is a communication tool that should be read bottom-up, starting with the objectives in the learning and growth perspective. Following all the cause-and-effect relationships in the map, we can see that the ultimate goal of the LS is to "improve student learning experience". Each of these strategic objectives are measured by a set of KPIs (key performance indicators) that are monitored in the faculty view by the course coordinator.

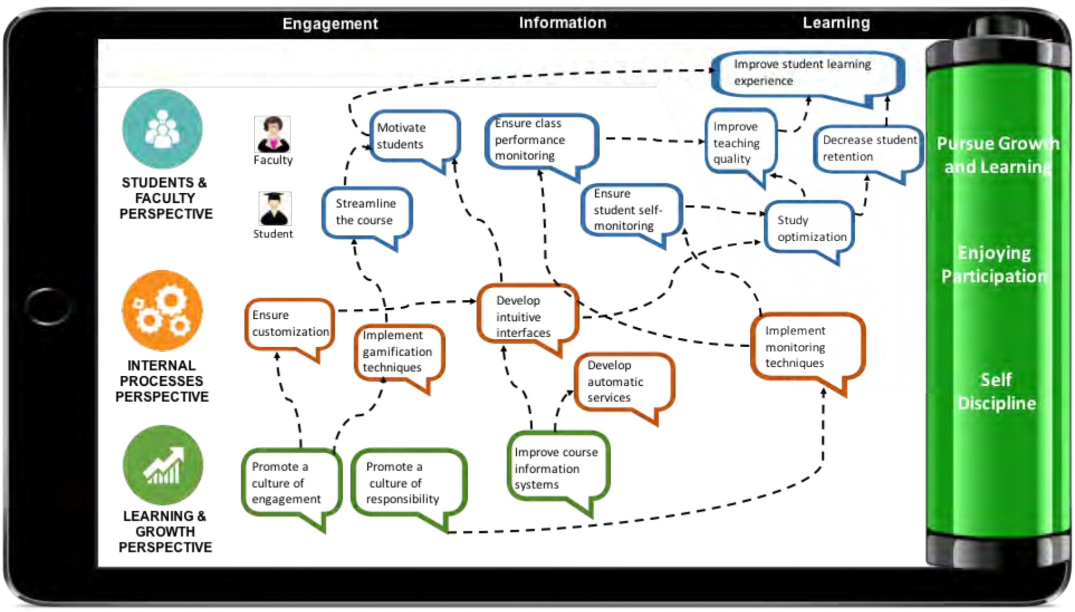

Figure 1: The Learning Scorecard strategy map

The LS uses gamification, a recent technique which is being applied to education and other sectors, that uses game design elements in non-game contexts (Deterding et al., 2011; Dicheva et al., 2015). Gamification is particularly important for the student view, and is used to engage and motivate students to experience the different learning challenges proposed by the course coordinator.

The Learning Scorecard receives data from two systems: the e-learning platform and the student academic system. An important design requirement is to have intuitive and user-friendly interfaces, in which the input data required from students should be kept to a minimum. Most of the required data is uploaded into the LS by the course coordinator, based on the course syllabus.

2.1. The student view

The LS student view focuses on time management and monitoring of the individual learning experience. Gamification techniques play a central role in the design of the student view, since the tool is supposed to be used voluntarily by students. Gamification enables the motivation of students in terms of achieving the course goals, and provides a healthy competition environment towards the best course performance. Currently, the LS uses the following game elements: experience points (XP), levels, quests or challenges, leaderboard, avatars, and rewards.

In the LS, students are divided into classes according to their program. Students begin with zero points, and are thus encouraged to learn to earn experience points, and increase their game level. Figure 2 presents an example of the entry page of the student view, for a particular student or “gamer”. In this page the student can visualize his/her performance (in points) and receive alerts about incoming quests deadlines. A summary of the leaderboard is always present (at the sidebar, in the left-down corner of Figure 2), with the top-5 gamers (ordered by points) and the ranking of classes, ordered by the number of active students using the LS. The identification of classes in Figure 2 is done using the Portuguese acronym of the program. Figure 2 presents real data (as of November 18, 2016), of a student enrolled in the Data Warehouse course in the winter semester of 2016-2017. In this semester the course was taught to four programs (respectively with the acronyms MEI, METI, IGE and IGE-PL): two master programs in the area of computer science engineering and two undergraduate programs in informatics and management.

Figure 2: The LS student view: quests and points

Students can also visualize the course planning, with a list of all planned quests, according to the course syllabus. There are mandatory and optional quests. Students receive experience points for concluding quests. Currently, the following type of quests are implemented:

- class assiduity (validated with the assiduity report generated by the student academic system; students have a university student card that needs to be activated at the location and time of the class)
- quizzes (performed using the e-learning system)
- exercises (also submitted to the e-learning system)
- practical assignment (entails a qualitative evaluation performed in a tutorial meeting with the teacher, in which students receive feedback on the development of the course’s practical assignment; for instance, in the case of the Data Warehouse course, this assignment was the development of a data mart).

The performance functionality in the student view includes three standard visualizations: progress analysis, percentage chart and radar chart. Figure 3 presents an example of the progress analysis dashboard for the top gamer at the time, in November 18, 2016 (week 9 of the semester, which comprises 12 weeks in total). Student performance is also presented in comparison with the average performance of the class, using a radar chart, as displayed in Figure 4. The percentage chart provides a visualization of the student’s current achievements versus the total amount of points that he/she could have earned so far in the different types of quests.

Student identification data privacy is an important non-functional requirement of the Learning Scorecard. That is, the course coordinator only has access to aggregated class data. What could be perceived as a missed opportunity (in terms of the identification of at-risk students) was in fact considered an advantage. The LS was mainly designed for students to support their learning experience in a course, as such in our perspective, student privacy contributes to the voluntarily use of the platform, removing any fear of faculty observation. Only the student nickname is shared in the leaderboard (see also Figure 7). Figures 2, 3 and 4 were kindly sent by students to the course coordinator for the purpose of documenting the LS usage.

Figure 3: The LS student view: performance visualization (progress analysis)

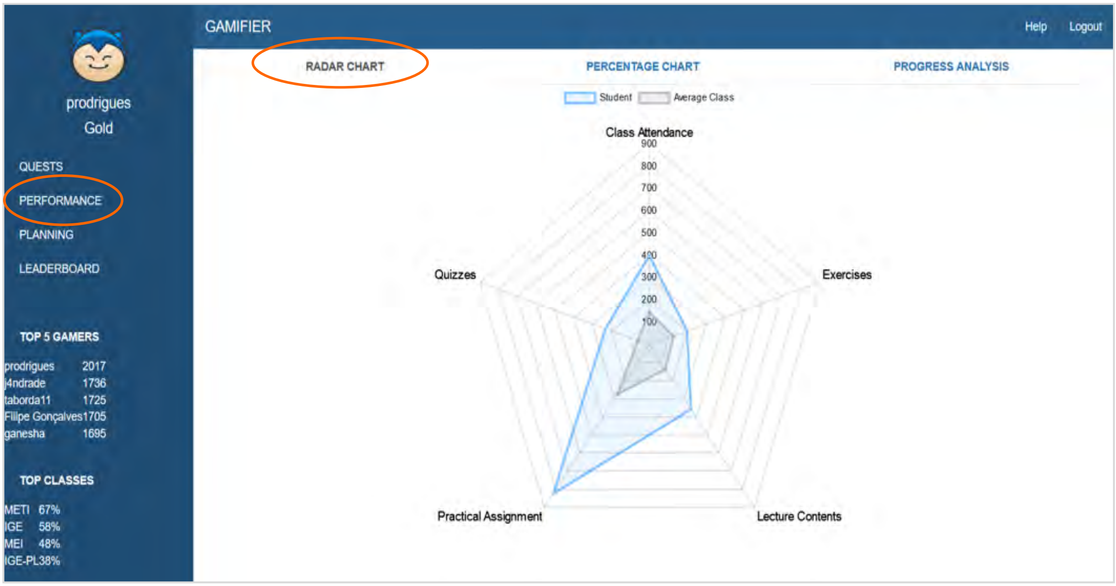

Figure 4: The LS student view: performance visualization (radar chart)

2.2. The faculty view

The faculty view is an essential part of the LS tool. The initial prototype of the Learning Scorecard only had the student view. The current version of the LS tool has both views implemented. As a result of the implementation of the faculty view some changes were introduced into the student view. In this paper the interfaces related to the student view are from the first version of the tool, whereas the interfaces described in this section belong to the second version of the tool.

In this view, the course coordinator can increase the communication with the students and customize their learning path. Figure 5 presents the planning functionality, in which the course coordinator can insert the list of quests for the course. This list will be later available in the planning option of the student view (see the sidebar in Figure 2 for example). Each quest has a type and a number of points that can be awarded. Figure 6 also presents the list of quests but using a timeline format. This is a new functionality, which is also available in the student view. The data displayed in Figure 5 is just test data, whereas Figures 6 and 7 display the current data in the platform.

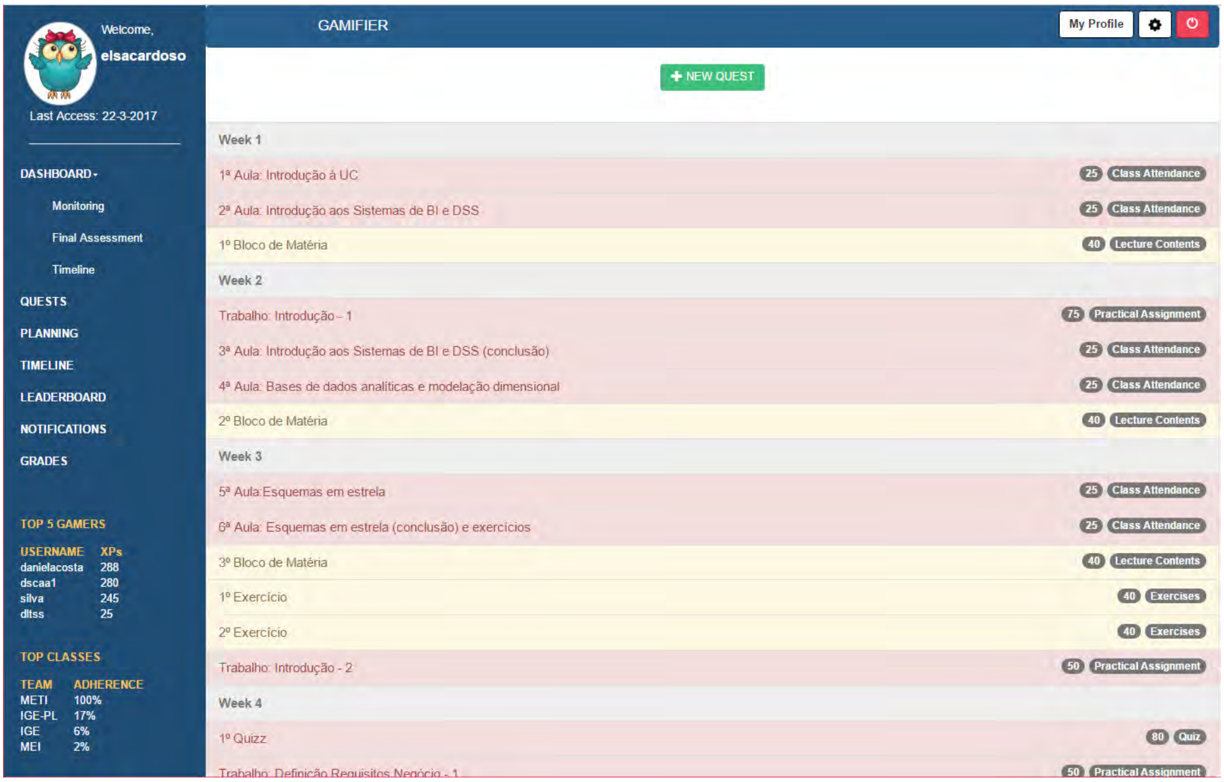

Figure 5: The LS faculty view: planning of all quests

With the Learning Scorecard the course coordinator can monitor the progress of students in terms of the following dimensions:

- Engagement
- Student motivation
- Student responsibility
- Study optimization
- Learning feedback
- Student collaboration

The monitoring functionality can be analyzed in average, considering the performance of all students enrolled in the course, or filtered by class. The LS is currently applied to courses that are taught to students of different programs. Hence the idea of using gamification to explore the “natural and healthy” competition among students from programs in related scientific areas.

Engagement is measured by three indicators: percentage of students registered / active / and inactive in the LS. Student motivation is measured by the average number of points (XP). Responsibility is measured by the number of quests performed and the average quest delay. Study optimization is measured by the percentage of completed quests within the course milestones. The learning feedback is calculated in terms of the average grade of the quizzes. Finally, student collaboration is assessed by the number of points awarded in posts submitted to the course’s forum (in the e-learning platform).

The faculty view is essential for the validation of quests. Class attendance, forum participation and and practical assignment are evaluated by the course coordinator. Assiduity data is imported from the university academic system. XPs gained through the participation in the course’s forum are introduced at the end of the semester. Each student will earn a percentage of the maximum number of 5000 XP, according to their participation (an excellent performance earns 100% of the forum XPs, a very good performance 80%, good 60%, satisfactory 40% and finally an inactive student receives 0 XP). There are also extra XP to grab in the forum. Extraordinary posts, that contribute to the collective learning of the class are awarded with 350 XP (each).

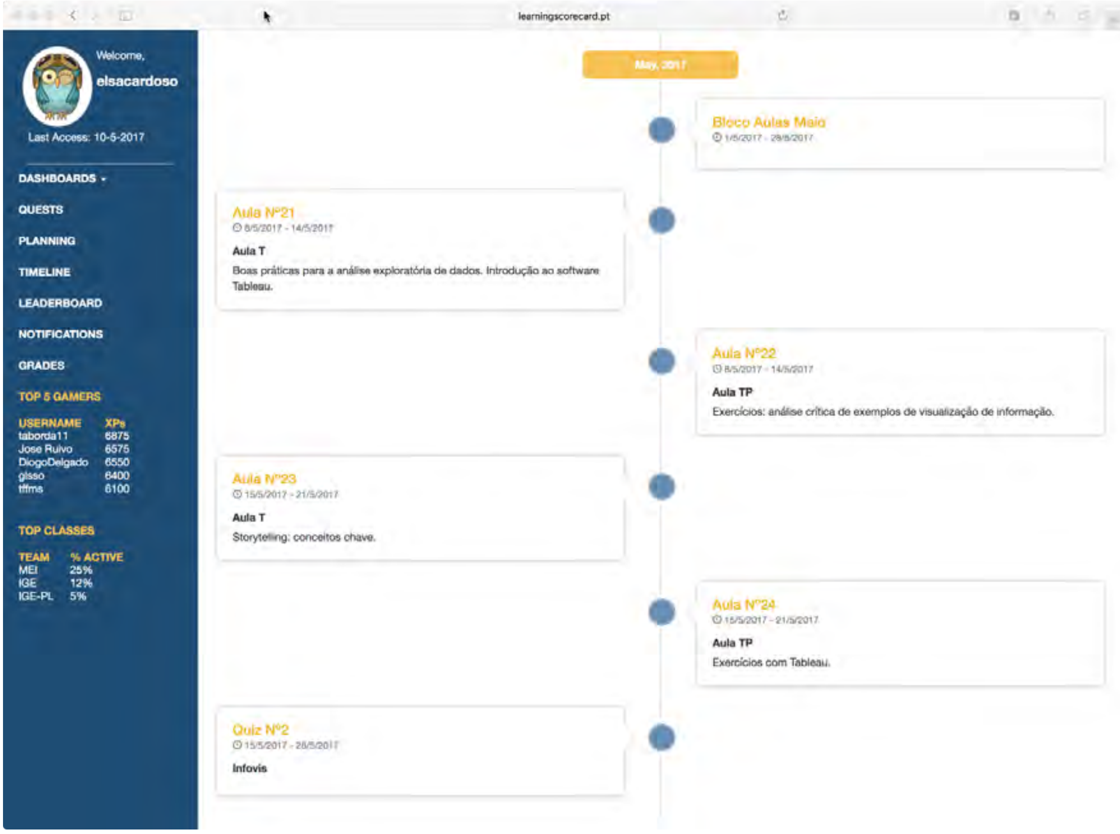

Figure 6: The LS faculty view: timeline

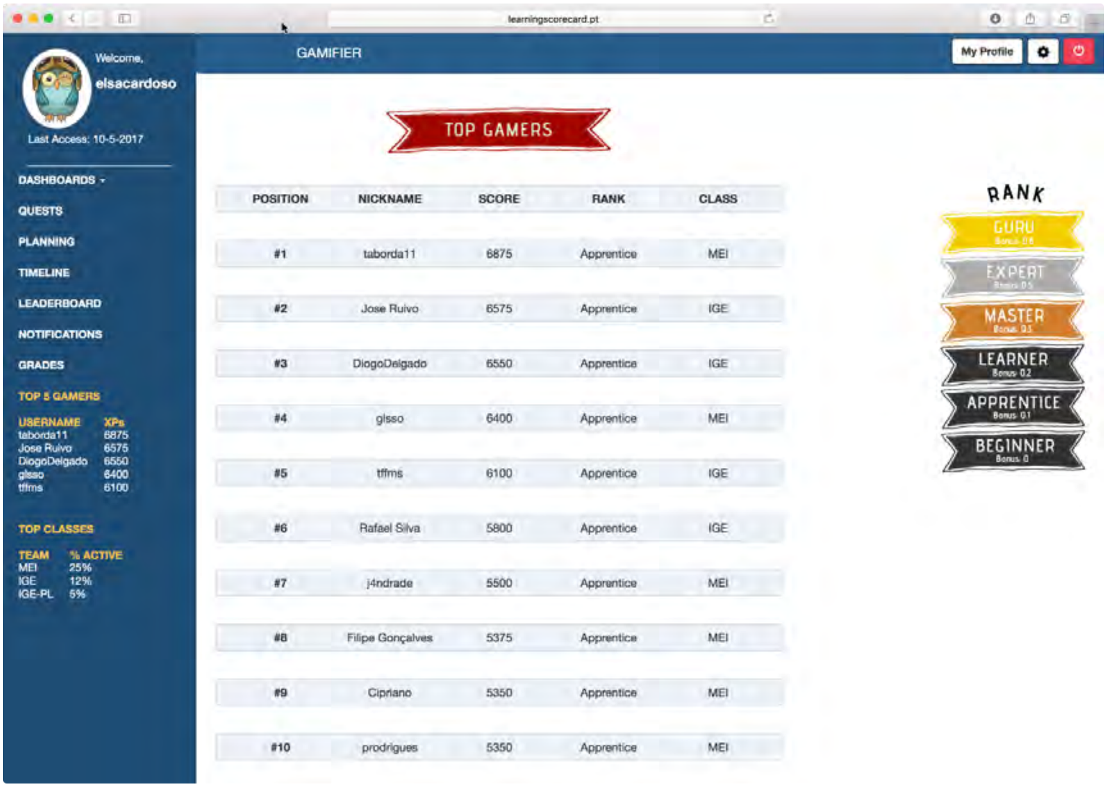

Figure 7: The LS faculty view: leaderboard and student ranks

3. PROTOTYPE DEVELOPMENT AND EVALUATION

Figure 8 describes the development process of the LS, which began in the Spring semester of the 2015-2016 academic year (more specifically in April 2016). The result of this initial development phase was LS version 1 (v1), only with the student view. This version was tested by an initial group of 110 students in a Data Warehouse course (labelled Course I in Figure 8), lectured in the 2016-2017 fall semester to four different programs. Data was collected from October to December 2016. At the end of this pilot study, students were asked to fill in an online questionnaire to assess student engagement, motivation, and satisfaction with the course and the LS platform. The feedback gathered from these questionnaires was essential to drive the next phase of development, which will be concluded by the end of March 2017. LS version 2 (v2) comprises both the student and faculty views. This new version will be tested in another course (labelled Course II in Figure 8), focusing on Business Intelligence and Data Visualization, which is also taught to students from (three) different programs. The coordinator of both courses is the same, which ensures a continuity in terms of the evaluation of the LS. The second study pilot will occur between April and May 2017. In June 2017, a new round of questionnaires will be sent to students to evaluate the performance of the tool and their perception of the impact of the LS to improve the learning experience.

The real impact of the tool can only be assessed with more case studies and in several academic years. Nevertheless, the impact on student grades will also be studied, in terms of final grades as well as partial grades (e.g., practical assignment and individual test), according to the pedagogic methodologies used in the courses. Taking this aspect into consideration, the initial selection of courses to evaluate the LS has already considered courses with similar pedagogic methodologies.

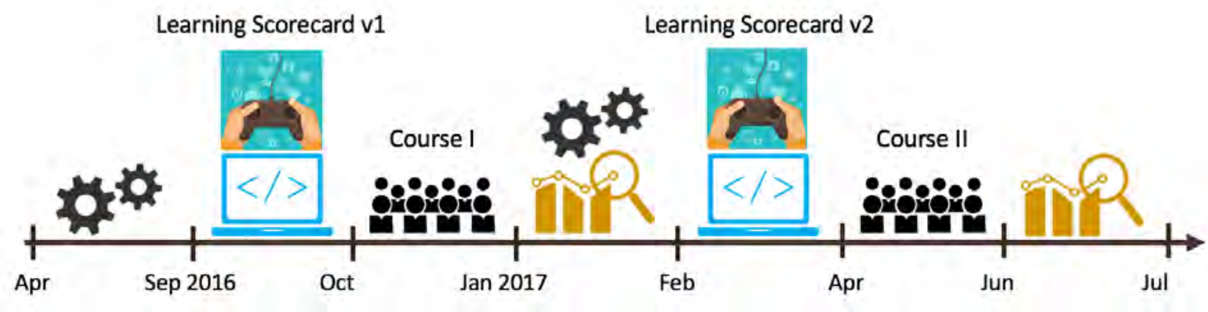

Figure 8: Learning Scorecard development and evaluation timeline

The LS platform was developed using Node.js. The front-end was developed using HTML and CSS. Javascript, specifically Express.js, was used for the back-end implementation. Several modules were used: Bootstrap, for platform design, Chart.js, for the implementation of the charts in the LS dashboards, Passport and Crypto, for secure authentication of students in the LS. The LS platform also includes a MySQL database.

3.1. LS version 1: feedback from students

At the end of the first pilot, students answered a questionnaire to evaluate the experience. The questionnaire was sent to students enrolled in the Data Warehouse course, and 54 students answered it, accounting for a response rate of 49%. Of these 54 students, only 37 (68.5%) had previously registered in the LS platform. The reasons for not having registered were: lack of time (main reason), and lack of interest or awareness of the platform.

Only 16.2% of students used the platform until the end of the semester, whereas 45.9% used the LS between two and four weeks[1]. When asked about the reasons why their motivation to use the platform faded, students provided the following feedback: “I missed one quiz and thought that I couldn’t win

[1] A semester comprises 12 weeks for lecture time.

the final top 3 rewards, so I gave up…", lack of time, "lack of motivation after the hacking situation…", validity of quests was ambiguous. The LS platform was hacked during the first pilot, after only two weeks of being online, and data from quests was lost. As a result of this incident, a significant number of students did not resume their game. The security of the platform was improved, but this issue had a major impact on the number of active students.

Despite the low usage figures, when asked if they enjoyed using an academic platform with gamification, 75% of students answered positively.

The received feedback was crucial to the improvement of the LS platform and the second pilot. Special attention was given to the previous reasons that led to the low adoption of the LS in the first pilot. The reward system was changed: the reward is now available to all gamers in a proportion of the total XP earned, as opposed to a top-3 ranking or podium (see Figure 7).

Another important aspect was the validation of quests. Most of the improvement suggestions received from students was related to the type of quests and their validation in the platform. All the received feedback (44 suggestions) was taken into consideration, which led to a much richer second version of the LS. In this new version of the platform, data input by students has been minimized, and unnecessary quests or quests which could not be objectively validated were deleted (such as the reading of slides or papers). The original mindset and values of the LS platform are: "pursue growth and learning", "enjoying participation" and "self discipline", as displayed in the strategy map of Figure 1. Students were supposed to validate only the quests they had actually performed – "self discipline" – only then the LS could be used to monitor their own learning path. However, students didn't perceive the "self discipline" part, and acted mainly with the reward in mind. With the new reward policy implemented it will be very interesting to see if the students' behavior will be different in the second pilot experiment of the LS platform, which is currently ongoing.

Notifications have been implemented in the faculty view, so that alerts can be issued when quests are about to end. The usability of the interface was also improved.

When questioned about *"how important is student data privacy for your participation as a gamer in the LS?"*, about 42% of students considered it important (33.3%) and very important (8.3%). In contrast, 27.8% considered data privacy not important and 8.3% even said it was totally unimportant. Regarding this issue, there are mixed feelings amongst the students, however, we decided to continue to ensure student data privacy.

Students mentioned that the LS and the e-learning platform should be completely integrated. For some of them, having two platforms was confusing. This is a very important remark. Blackboard is the e-learning platform used at ISCTE-IUL. All the functionalities that were already available in the e-learning platform were not programmed into the LS, for instance, quizzes and the forum. Regarding quizzes, the grades are imported to the LS, and students are only asked to evaluate the difficulty of the quiz (in a scale of low, medium, high).

4. CONCLUSIONS AND FUTURE WORK

This paper presented a new tool designed to improve the student learning experience, the Learning Scorecard. The LS receives data from the e-learning platform used at the university and the student academic system (for the assiduity data). The e-learning platform is used to run quizzes and specific challenges (such as practical exercises), and also to encourage student collaboration via the course's forum. The LS was designed to complement the e-learning platform, adding game elements to the student view to increase their motivation and engagement with the learning process. For the course coordinator, the LS provides a comprehensive and customized view of the learning experience of students that significantly extends the current functionalities available in the e-learning platform used in the university.

A lot is planned for future work. Research is being developed in terms of the reward mechanisms integrated with game dynamics, with the purpose of increasing and maintaining the motivation of students to use the tool, and ultimately pursue a better final grade. The goal of the Learning Scorecard is to improve the student learning experience, as a process but also as an outcome. In the future, the LS may also be applied to other courses in different scientific areas, other than Decision Support Systems and Business Intelligence (for instance, in Mathematics and Architecture). The development of a mobile app for the student view is also planned for the next academic year. It is also possible to generalize the use of the Learning Scorecard to other universities, however, significant development is required. The concept of the LS is very rich; another group of students is currently developing a new module to study academic success and the link to pedagogic practices in courses using data from one program. The original ideal behind the development of the LS was to actively involve students in the learning process, making them aware of the key factors that impact their learning experience in Higher Education. At the same time, the LS platform is also a great example of a business intelligence and learning analytics application, attempting to measure and manage indicators of the learning process, which is something that students can relate to.

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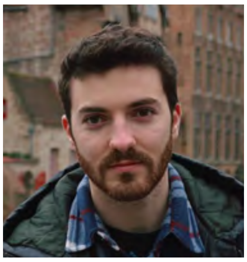

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Electronic Document Workflow and e-Signature Implementation at Riga Technical University

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Keywords
e-Signature, Electronic Document Workflows, Document Management System.

1. SUMMARY

The paper describes a pilot-project of implementing a custom-developed module for electronic document workflows and e-signature at Riga Technical University, Latvia. The module is developed in-house and uses official e-signature technology in Latvia to provide RTU management and staff with a tool for efficient document workflows in existing Document Management System (DMS). A business need, the project scope and benefits of the developed solution are outlined.

2. EXTENDED ABSTRACT

In 2016 Riga Technical University (RTU) set up a cross-university project to implement electronic document workflow and e-signature module in existing RTU Document Management System (DMS). The project was initiated to meet a business need of solving the problem of unefficient document life-cycle at the university: document creation, approval, dating and signing are performed manually outside of DMS, and then scanned and registered in DMS. The business need was defined from the middle management with a goal to facilitate a broader adoption of e-signature at the university, to improve collaboration between document authors, approvers, and external entities, timeliness of document life-cycle, and to increase document security.

A project group, consisting of members of Document Management Department, IT Department, and Administrative Department, was set up to investigate the options and alternatives for improving administrative staff productivity by implementing electronic document workflows and signing document electronically with the official e-signature technology in Latvia.

A change-driven approach to the project was chosen. The project team was focused on rapid delivery in short iterations. Business analysis effort was based on the best practice described in (IIBA, 2009), and produced an initial list of high-level requirements, this backlog was then updated throughout the project as new requirements have emerged. Throughout the project, these requirements were prioritized and reprioritized based on the business need. The highest-priority requirements were taken from the backlog for detailed requirements analysis, and implementation began as soon as analysis was complete.

The developed solution includes the following steps: (1) a document author prepares MS Word document in DMS using predefined template (templates are available in several languages), (2) WebDav protocol is used for MS Word and DMS integration: the prepared document is saved in DMS, and a user is able to edit the document in MS Word and save changes to the server, (3) the document author starts a workflow by defining a list of internal approvers (sequentially or in parallel) and a person who will sign the document (either with e-signature or by hand), (4) when the workflow is successfully completed, the document can be signed with e-signature or can be printed out and signed by hand, (5) multiple documents can be signed with e-signature at the same time, and (6) e-signed document is then sent out from the DMS to the recipient.

Documents are electronically signed in the client side using Java desktop application developed by RTU Department of Information Technology. The solution uses Java 8 version and is based on JavaFX software platform (ORACLE, 2016) which provides tools for rich internet application development and could be executed on more than one operating system. In order to provide an opportunity to safely sign documents the application uses the official Java EDOC library developed by SJSC Latvia State Radio and Television Centre (LSRTC, 2016), the only Trusted Certification Services Provider in Latvia. EDOC is a file format that contains an archive with signed/unsigned files. The library contains all the necessary functionality for EDOC integration in custom applications. There are methods for EDOC creation, classes for adding and removing data files, functions for adding and validating digital signatures. The Java application launch is carried out by Java applet or browser extension.

One of the most important issues of e-signature and electronic document workflows is security and confidentiality (Jaju & Chowhan, 2015). In order to limit the number of web resources which can run the application – certificates are used. The data exchange between the web resource and a user desktop application is possible only if the resource certificate has been added to the user's certificate trust store. For security reasons file checksums are calculated before EDOC signing and compared with the Java desktop application initialization parameters.

The potential benefits of the developed approach are as follows: (1) a step towards Green IT, e.g., reduced paper use, (2) cutting costs ("lost time" costs of RTU management by signing document by hand, scanning costs, disposal costs, etc), (3) efficient document management business process, (4) employee satisfaction, and (5) improved collaboration and version control.

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Software development process and testing legislative acts

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Keywords
Regulatory Impact Analysis, testing, development model

1. ABSTRACT

The purpose of this paper is to describe legislative process using the terms of software engineering and to propose some new manners of detecting and avoiding defects in new law acts. The idea of software tester's approach to lawmaking comes from the observation that software development and legislative process are similar. Paragraph 2 contains an explanation of that similarity, definition of some basic software testing terms and a basic discussion on the topic. Paragraph 3 presents some basic software development models. In paragraph 4, one can find a brief description of the legislative process in the Republic of Poland. Paragraph 5 contains a discussion on concepts concerning making better law. I give two new ideas: dividing legislative bills into two documents and setting off the Law Testing Committee, that would lead to better validation and verification of legislative acts.

2. INTRODUCTION

A general process of creating a statutory act (or other law document given by legislative or executive authority) and a software development process, apart from obvious differences, have some key similarities. Both, statute and computer system, start as an idea (that solves a problem, meets a need, a must, etc.) which is later put into life. More generally, a legislative can be seen as a 'factory of law', and described as any other factory – how it is organized, how does its production process look like etc. More particularly, a group of people write a sequence of characters (signs) which can be discussed, modified, and in the end is approved and comes into life. What legislators write is a natural language, and what software developers write is a programming language. A document created using a programming language is called a code. More generally, any (natural) language is a code itself.

A legislator (lawmaker, rule-maker) and a software developer (programmer, software engineer) constitute a pair showing similarities or things referring to both law making an computer system making. A legislator can be called a 'law (bill) developer' or 'law engineer', a software developer give rules, according to which a computer will behave. Also a computer programming language and a natural language (especially formal, used by lawyers or authorities) constitute such a pair. Obviously, neither programmers' nor lawmakers' work consists of writing only. Both, law making (law development) and software development, processes include decision making, problem solving, verification and validation. Differences between the law development and the software development show in the way those processes are organized. The reason of the differences come not only from the difference between software and law itself, but also from different approaches to their development models. Those models are discussed in paragraphs 3 and 4.

Verification and validation are terms related to software testing, a sub-discipline of software engineering. The International Software Testing Qualifications Board (ISTQB©), international software testing qualification certification organization, in its glossary – *Standard Glossary of Terms used in Software Testing (Version 3.1)* – give the following definitions of those terms.

Definition 1. Verification – confirmation by examination and through provision of objective evidence that specified requirements have been fulfilled.

Definition 2. Validation – confirmation by examination and through provision of objective evidence that the requirements for a specific intended use or application have been fulfilled.

In other words, verification is the process of ensuring if the software is made the proper way, while validation is ensuring the proper software is being made.

Both law and software, as made by humans, can be done incorrectly. As discussed in paragraphs 3 and 4, in general there is no particular moment when a final version of a bill is verified and validated, while software testing teams play an important role in software development life cycle. The aforementioned software testers' glossary gives definitions of three basic terms referring to incorrect human actions.

Definition 3. Error (mistake) – a human action that produces an incorrect result.

Definition 4. Defect (fault, bug) – a flaw in a component or system that can cause the component or system to fail to perform its required function, e.g. an incorrect statement or data definition.

Definition 5. Failure – deviation of the component or system from its expected delivery, service or result.

The definition of an error can be applied to bill development without any further comment. To help apply 'defect' and 'failure' to statutes, we need two more definitions, cited after (Frith, 2012).

Definition 6. Loophole – an ambiguity that can be used to circumvent or otherwise avoid the express or implied intent of the law. It is a technicality that allows a person or entity to avoid the scope of a law or restriction, to get around it in a way that was not intended by the legislators who put the law or restriction into place, without directly or technically breaking the law.

Definition 7. Unintended (unanticipated, unforeseen, unexpected) consequences (results) – outcomes that are not the ones that were intended by a purposeful action.

A loophole in an legislative act is an example of a defect and every usage of the loophole is a failure. Also, every unintended result is a failure of the act (one can observe that the definitions of unintended consequence and failure actually treat about the same thing: unexpected result). Note that a defect, which is a result of a developer's error, does not have to lead to a failure, e.g. when the developer specifies what is to happen in an impossible case – such situation would simply not occur and thus will have no (unexpected) result.

Although general rules of developing a bill can be similar for all or most developed countries, each country has its own particular model. Differences between those models can result in differences in amounts of defects and failures in law of the countries. Comparison of the quality of law in different countries is not an interest of this paper. Paragraph 4 describes the situation in the Republic of Poland. Paragraph 5 contains a discussion on how to organize a legislative acts development model so that the acts would be given proper validation and verification, similarly to software being tested.

3. SOFTWARE DEVELOPMENT MODELS

Many different approaches to software development have been used since the early years of information technology. This paragraph mentions only few of them. Those will form a background for the discussion in the next paragraphs. The models are not described in full, as this is not the aim of this paper, and one can find rich literature about this topic. A stage of testing and its role in the process is discussed.

The first important software development model is the waterfall. It consists of several steps, that occur one after another, always in the same sequence (like water falling on rock steps of a cascade waterfall, which is the explanation of the model name). Typically, the waterfall model steps are:

1. Defining software requirements
2. Analysis resulting in models and business rules
3. Designing of the system resulting in software architecture
4. Implementation (programming)
5. Testing

In this model, the whole computer system, with all its complexity, is tested at once, when it is ready. Any defects are repaired after the testing is finished (the process steps back to step 4), and another testing process is proceeded after all defects are repaired. The processes of testing, repairing and re-testing are repeated several times. In this approach, bugs (especially caused by mistakes made in documents created in steps 1-3) are found relatively late (implementation can take months or years, depending on the system), which makes repairing them difficult and expensive, related to other development models. A way of coping with this problems of the outdated model is the V-model.

The V-model can be considered as an extension of the waterfall model. A common type of V-model uses four test levels, corresponding to the four development levels. The name of the model comes from the letter V shape: the development stages are the left side and the test stages are the right side of it. The steps are:

1. Business requirements
2. System requirements
3. High level design
4. Low level design
5. Coding
6. Unit testing
7. Integration testing
8. System testing
9. Acceptance testing

When V-model is the one applied, acceptance tests can be designed or prepared when its corresponding phase – business requirements – just ended and the system requirement step is in progress. Similarly, system testing is designed after system requirements are documented, integration tests are designed after high level software design is ready. Low level design, coding and unit testing can be made by the same person – a developer, who designs, implements and test their own code. Early preparation of test levels can result in finding mistakes (especially mistakes in design) relatively early. Still, the testing process takes place after the software is finished.

A much different approach show agile software development models, a modern example of an iterative-incremental development models. Iterative-incremental models use a series of short development cycles (iterations), that last one or few weeks. In each cycle a small amount of work is made, using a small waterfall, V-model or similar model for designing, implementing and testing a small part of the developed computer system. Each cycle ends up with a working software delivery. The aim is to make the developed computer system evolve every cycle. Testing takes place when a new part of computer system is ready – during the same iteration it was designed and implemented. Defects found just few days after they were produced, have small influence on the rest of the system, which makes them easy and cheap to repair.

Testing within a software life cycle model

Another document created by ISTQB©, *Certified Tester. Foundation Level Syllabus (Version 2011)*, gives some rules related to software testing, that are independent from a software development model. In any model, there are several characteristics of good testing:

1. For every development activity there is a corresponding testing activity.
2. Each test level has test objectives specific to that level.
3. The analysis and design of tests for a given test level should begin during the corresponding development activity.

One more rule can be added: testing does not end when the developed system is deployed – e.g. validation of a deployed system can show, that the users' needs have changed, or the users simply found bugs, that had not been found by the software testers.

4. LEGISLATION IN POLAND

The legislature in Poland is a bicameral parliament consisting of a lower house (Sejm) and a Senate. Article 118 of the 'Constitution of the Republic of Poland' states:

1. The right to introduce legislation shall belong to Deputies, to the Senate, to the President of the Republic and to the Council of Ministers.

2. The right to introduce legislation shall also belong to a group of at least 100,000 citizens having the right to vote in elections to the Sejm. The procedure in such matter shall be specified by statute.
3. Sponsors, when introducing a bill to the Sejm, shall indicate the financial consequences of its implementation.

The proposition of a new law is considered in three readings in the Sejm. It starts form the Marshal of the Sejm, who decide whether the first reading is to be proceeded by the whole house or by its committee. The bill is then considered by committee(s) between first and second reading. During the committee's consideration, the bill can be amended. The second reading is held before the Sejm. After that, the bill can be considered by committees again – in that case, amendments are debated by the committees and the bill together with the committee's report is sent back to the Sejm for the third reading. If the Sejm does not decide to send the bill to a committee, the suggested amendments are discussed and voted in the third reading. After the third reading the bill is sent to the Senate.

The reading in the Senate can end up in three ways. One is accepting the bill without amendments. In that case, the Marshal of the Senate sends back the bill to the Marshal of the Sejm, who sends it to the President of the Republic of Poland.
The second possibility is amendment of the bill by the Senate. Then, the Sejm accepts or rejects the amendment and the Marshal of the Sejm sends the bill to the President.
The Senate can also request for cancellation of the bill. The request can be accepted or rejected by the Sejm. In the latter case, the Marshal of the Sejm sends the bill to the President.

The President of the Republic of Poland can sign the bill (new act) without further consideration, can ask the Constitutional Tribunal whether the bill violates the Constitution or send the bill back to the Sejm.

If the Constitutional Tribunal states the bill is unconstitutional, the bill is canceled. If it states the bill is partially constitutional, the President signs the bill with some parts canceled. If the tribunal states the bill does not violate the Constitution, the President signs the bill.

If the President decide to send the bill back to the Sejm, the lower house can amend the bill or send it to the President back without amendments – the President has to sign the act then, or cancel the bill.

All this process (described in a simplified form) is more complicated than the software development models. Trying to compare this process to the software development, one can observe the following stages:

1. Defining requirements, analysis and implementation (before the actual legislative initiative)
2. Discussions and amendments
3. Testing and decision making

Testing here means searching for loopholes and anticipate the results of the new law. The first and second steps require good will from the persons involved in the process for the bill to be tested. In step 3, the President (one person) can test the bill or ask the Constitutional Tribunal (15 judges) to test it. Defects found by the President on this stage (the acceptance tests) are expensive to repair and defects found by the tribunal require setting off a new process, with a new bill draft.

Amendment are, in theory, made to improve or repair a bill. But they cannot be treated as testing, because they can cause new defects – in fact, amendments are a part of the implementation process, similarly to bug fixes in the software development process.

However, one element of testing (anticipating the results) is required by the Constitution. As cited earlier, sponsor of the bill have to indicate the financial consequences of its implementation.

The Council of Ministers' bills

The discussion above omits one important situation: legislative initiative of the cabinet. In practice, most of the bills are prepared by the Ministers or the Cabinet. The Statute of the Council of Ministers, see *Regulamin pracy Rady Ministrów* in Polish, specifies the cabinet bills development process. Its key features are public consultations and obligatory Regulatory Impact Analysis (throughout this article called 'RIA'). RIA in general is a document, that should be created before introducing a new regulatory act in any OECD member country. Its role is to provide an anticipation of outcomes and potential impact of the new law. RIA in Poland refers to cabinet bills only, as it is mentioned only in the aforementioned Statute. The document shows expected results of the proposed bill, concerning social and economic affairs. In particular, according to the Statute, RIA in Poland contains:

1. who the act is going to affect,
2. information about the public consultation results,
3. results of analysis of the bill influence, especially on the budget, employment, competitiveness of the economy and condition of companies,
4. sources of funding the cost of the proposed act,
5. data used in the analysis.

In practice, many Minister's bills do not become the Cabinet's bills, but to make the bill be processed faster, it is proposed as a Members' of Parliament bill. On the on hand, RIA (together with public consultation) can be a good early-stage testing tool, on the other, it is easy to by-pass. What is more, many amendments are made after RIA is completed which makes RIA outdated during the parliament's readings.

Another disadvantage of the Polish implementation of RIA is the fact, that RIA is prepared by the same persons as the bill itself, and no other RIA can be prepared (by third party, someone distanced to the bill). This stands in opposition to software engineering approach, where software testing (except low-level testing done by the programmer) of a part of the computer system is proceeded by other than its author team members. Moreover, legislators writing a draft bill and RIA tend to see only the advantages of their draft. This results in RIA being a form of and advertisement of the proposed bill.

Public consultation of the Cabinet's bill play a similar role to user acceptance tests in software engineering. The difference is that a draft bill is put under public consultation, while user acceptance concerns a ready or almost ready to use computer system.

5. CONCEPTS AND CONCLUSIONS

Testing in law development process in Poland includes public consultation and Regulatory Impact Analysis. Parliament readings of bills and the Presidents decision should also include validation and verification. This not much enough to state that the new law in Poland is tested as thoroughly as needed, and that is tested in a similar way a software is. Ease to avoid public consultation and RIA (as mentioned in the previous paragraph) makes testing law only an option, a sign of good will. From a software tester's point of view, law testing should be a formal part of law development process. There are few ideas on how to achieve this state.

One of them is constituting the State Council, proposed by Janusz Kochanowski (Kochanowski, 2005). The Council would prepare RIA for all bills and check any formal criteria a bill should meet. The Council was supposed to be an independent body, similar to the Constitutional Tribunal, but working on bills *ex ante*, not on acts *ex post*.

Another idea, also suggested by Kochanowski, is the usage of the sunset provisions, *'according to which a passed legal act becomes automatically null and void unless a political will of its retention is expressed within a specified period of time'*. A political will of retention of a faulty act makes an occasion to amend the act, fixing the defect. A lack of such will would result in vanishing the faulty law.

The Kochanowski's State Council would opinion bills before the Sejm readings. From a software tester's point of view, that is a right stage for testing the general aim and idea of the bill, but RIA should be made also in the end of the parliament's process. I suggest two major changes in the law development process.

One is a change in the artifacts. When a software is developed, analytic documents are developed, describing both the business and technical requirements, and then there is the implementation stage (no matter if it is the implementation of the whole system in the waterfall model or implementation of one particular use case in an agile model). Similar division may be made in bill-making – first an analysis, the requirements, second the bill itself. Discussion and voting during the parliament readings would refer separately to the requirements, and separately to the bill, first validating the purpose of the bill, second – verifying whether the bill meets the requirements. Both the analysis document and the bill would be amended by the parliament.

The second change is constituting the Law Testing Committee in the Sejm, which role would be to update RIA after each stage of amendments of both the bill and the bill analysis. Such up-to-date RIA document would be an equivalent of integration and system tests of a computer system.

Reformulation of the law development process to make it more similar to software development processes can make detecting and avoiding defects in acts easier. Furthermore, it can make the whole process easier to maintain and manage, making it also more transparent. Transparency of the legislative process is a must in a democratic state ruled by law.

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Usability Evaluation of University Websites

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1. ABSTRACT

If the company doesn't have a website, it is losing out on great opportunities for its business. A website itself can be used to accomplish many different marketing strategies to help the business grow. Companies can benefit from having a website. Websites are nowadays used not only as a sales method and information tool, but also as a communication tool in marketing. (Kvasnicova, Kremenova, Fabus, 2015)

Schools and universities have a special place in the market. They offer education opportunities in particular areas. The educational institutions market is huge and extremely competitive. Although the reputation and the quality of institutions is a major advantage, they must think about the target group, who are young people spending several hours per day browsing websites. Schools and universities should have their own web pages, which represent them and perform many functions: information, communication, publications, cultural, and social, among other activities. University websites are intended for employees, high school students interested in studying, school partners, public authorities and the general public. (Kvasnicova, Kremenova, 2015)

The most important is that the web pages are usable – it means it is easy to use the website, user find what are looking for. Otherwise, visitors leave them and click on the competitor's website.

The word usability has become the most inflected in the design and management of web sites and applications worldwide in recent years. Nielsen (1993) defined usability as a quality attribute - something that is easy to use.

We are able to evaluate the usability. One of the common tool is System Usability Scale (SUS), which provides a "quick and dirty", reliable tool for measuring the usability. (Brooke, 2013) It consists of a 10 item questionnaire with five response options for respondents; from strongly agree to strongly disagree. Originally created by John Brooke in 1986, it allows us to evaluate a wide variety of products and services, including hardware, software, mobile devices, websites and applications.

We examined how the current situation in Slovakia is. There are no statistics for measuring and evaluating the usability of university websites. To fill this information gap, we conducted several interviews with administrators of schools websites. The interviews have shown that such a usability test have not been made. Therefore we formulated the research problem: Usability evaluation of universities websites and decided to find out the current situation. Research determine how many of universities in selected countries (Slovakia, Czech Republic and Finland) evaluate the usability of their web pages. We expect: More than 90% of schools do not evaluate the usability of their web pages.

Due to the existence of information gaps and our concern for them to be completed, it was a plan of the research project in two main steps. Step 1: We ask administrators from all universities and colleges in 3 selected countries to fill in a questionnaire. The main question will answer our research problem.

Step 2: We ask high school students to evaluate university websites by using SUS tool. The period of our research is from beginning of February to the end of May 2017.

The results offer insight into the current state of usability of universities website in selected countries. We can identify the weaknesses of websites and propose to remove them. Thanks to the results we are be able to improve website usability, make it more comfortable and easier for users.

2. INTRODUCTION

Humanity, while in existence, is still looking for ways to improve the processes and things that serve it. Today, we can imagine neither work, nor a common life without the Internet. According the Internet world stats (2017) nearly 50% (49.6 %) of world population are internet users. Companies understood the advantage of online presentation really quickly and in many cases had change offline sales to online. Also governments are trying to use e-government applications to save money and time, and also to provide more comfortable services to the public. In the same way, universities have developed website to inform applying students about study programmes, current students and employees about daily topics and to provide other e-services, and also to other institutions and organizations. The educational institutions market is huge and extremely competitive. Although the reputation and quality of institutions is a major advantage, they must think about the target group, who spend several hours per day browsing websites, and try to reach their attention.

There are over 1 billion websites on the World Wide Web today. But only a small percentage of these websites reach the basic level of visitor satisfaction. Customer satisfaction, efficiency, and effectiveness are three aspects of usability. Usability answer the question: how easy is something to use.

It is important to pay attention to usability of university website and to improve the level of visitor satisfaction. Hence, it is necessary to evaluate usability. The best known studies are two by the US Company Nielsen Norman Group. In the first study, they evaluated 109 university websites and then developed a guideline with 78 recommendations. In the second research, 57 universities had been evaluated and research team developed a design guide with 10 major recommendations. (Sherwin, 2016) Another bigger evaluation was in the United Kingdom of Great Britain and Northern Ireland, where research team evaluated 110 university websites by using big data. (Alqurashi and Wang, 2014) Smaller studies were also conducted in the USA (Andrews and Walsh, 2006), Malaysia (Jabar, Usman, Awal, 2013), Spain (Fernandez, Insfran, Abrahao, 2011) and Turkey (Sengel, 2013, Peker, Kucukozer, Cagiltay, 2015). The following tools were used for evaluating level of usability: user testing, questionnaire –SUS, WAMMI, graphic presentation, guideline, and systematic mapping. Findings from different studies inform us about poor usability of university websites. The main usability problems were: wrong context, inappropriate design, weak navigation, bad terminology, poor attractiveness, poor functionality, poor accessibility, lacking of drop-down main menu structure, irrelevant location of desired information, and bad usage of external files.

3. LITERATURE REVIEW

The word usability has become the most inflected in the design and management of web sites and applications worldwide in recent years. Usability is defined in ISO 9241-11: "Usability is the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use". Nielsen (1993) defined usability as a quality attribute - something that is easy to use. More particularly it relates to how quickly a person can learn something used as effective in use, such as the use memorable as prone to making mistakes and how happy "to" users use (Nielsen, Loranger, 2006). Krug (2006) as a basic rule for creating web pages considers that the creators of pages do not force users to think. In the web interface is therefore necessary to provide the user with an environment with which will have to learn to work. You cannot require users to study manuals guide when they are only interested in specific information. The user interface must be intuitive and frugal. Usability theory has been developed and numerous usability evaluation tools have been introduced during the last 30 years.

Methods of usability evaluation can be categorized into expert based approach – include evaluators and user based approach - include representative users. Expert based approach methods are: 1. Model based (GOMS, MUSiC, DRUM, AIDE, QUIM, GUIDe, TAM), 2. Expert evaluations, 3. Personas and

Scenario, 4. Analytics, 5. Others (Case study, Card sorting, A/B testing, Brainstorming, Benchmarking). User based approach methods are: 1. User testing evaluation, 2. Pluralistic Walkthrough, 3. Interview, Questionnaire, Focus group, Workshop, 4. Questionnaire based methods (SUS, WAMMI, QUIS, SUMI, ASQ, PSQ, PSSUQ). (UsabilityNet, 2006)

We introduce some of the methods more detailed below.

Remote usability testing allows researcher to conduct user research with participants in their natural environment by employing screen-sharing software or online remote usability vendor services. In general, tests should be about 15–30 minutes long made up of about 3-5 tasks. (usability.gov, 2017) Tests can be "moderated", where is real time communication between the researcher and the participant, or "un-moderated" where participants complete the tasks independently.

System Usability Scale (SUS) provides a "fast and dirty" but reliable tool for measuring usability. The questionnaire consists of 10 questions with scale responses; from I strongly agree to strongly disagree. The list of questions is below:

1. I think that I would like to use this website frequently.
2. I found the website unnecessarily complex.
3. I thought the website was easy to use.
4. I think that I would need the support of a technical person to be able to use this website
5. I found the various functions in this website were well integrated.
6. I thought there was too much inconsistency in this website.
7. I would imagine that most people would learn to use this website very quickly.
8. I found the website very cumbersome to use.
9. I felt very confident using the website.
10. I needed to learn a lot of things before I could get going with this website.

SUS was created by J. Brooke in 1986. It is used to evaluate a wide range of products and services, including hardware, software, mobile devices, websites and applications. Scoring is complex - the participant scores on each question are converted to a number, the points are added together and the sum is then multiplied by 2.5, which will help to convert the original score 0-40 to 0-100. Based on the research, the SUS score over 68 points is considered above average and anything below 68 points is below average. The result is served by the scale (25 = terrible, 38 = weak, 52 = OK, 72 = good, 85 = excellent, 92 = best). (Brooke, 1986, Sauro, 2011, Brooke, 2013)

In the aforementioned studies were used SUMI and QUIS. SUMI (Software Usability Measurement Inventory) is a method, which was created in 1993 at the University of Cork. The questionnaire contains 50 questions. In 1996/1997, in cooperation with Nomos Management AB in Stockholm, the original methodology was modified and developed to the new version called WAMMI (Website Analysis and MeasureMent Inventory). WAMMI uses a 20-questions questionnaire. WAMMI finds the satisfaction of website visitors. Visitors are asked to compare their expectations with their real site experiences. Today it has an online version with a graphical view of the results and is offered commercially. (Kirakowski, Corbett, 1993, Kirakowski, Cierlik, 1998, WAMMI, 2017)

The last method based on the use of a questionnaire and user satisfaction ratings were developed in collaboration with psychologists, is called QUIS (Questionnaire for User Interaction Satisfaction). The QUIS 7.0 is the current version. It contains a demographic questionnaire, a measure of overall system satisfaction along six scales, and hierarchically organized measures of nine specific interface factors (screen factors, terminology and system feedback, learning factors, system capabilities, technical manuals, on-line tutorials, multimedia, teleconferencing, and software installation). Each area measures the users' overall satisfaction with that facet of the interface, as well as the factors that make up that facet, on a 9-point scale. The questionnaire is designed to be configured according to the needs of each interface analysis by including only the sections that are of interest to the user. (Chin, 1988, University of Maryland Office of Technology Commercialization, 2017)

4. METHOD

We divided our study into two steps as we describe below.

Step 1: We asked administrators from all universities and colleges in 3 selected countries to fill in a questionnaire. Our research problem was: Usability evaluation of university websites. We decided to find out the current situation. Research determine how many of universities in selected countries (Slovakia, Czech Republic and Finland) evaluate the usability of their web pages. Our expectation is: More than 90% of schools do not evaluate the usability of their web pages.

Table 1 shows the total number of universities by countries. Total number of universities is 142 in all three countries.

Table 1: Number of Universities by countries

Country	Slovakia	Czech Republic	Finland
Number of Universities	35	69	38

We chose a margin error of 10% (Δ=0.1) and a confidence level of 95%. Then t = 1.96. ð = √ (p*(1-p)). We have to emphasize that we are aware that we use the calculation of the standard deviation for the alternative division. We used this formula to calculate representative sample size for each country:

Formula 1: representative sample size

$$n = \frac{N * t^2 * \sigma^2}{(N-1) * \Delta^2 + t^2 * \sigma^2}$$

Require sample size for Slovakia is: n = 24 respondents. Require sample size for Czech Republic is: n = 40 respondents. Require sample size for Finland is: n = 26 respondents.

We sent questionnaire by emails to all universities, either communication managers, or administrators. The questionnaire has introduction and four parts. In the introduction we introduce our study and give the main information how to fill in the questionnaire. The first part contains of questions about how the website was created. The questions in the second part ask if the website has be ever evaluated, what kind of methods were used during evaluation and what were the results of evaluation. The third part of the questionnaire ask if they utilize data from Google Analytics, if so, what kind of data and how it helped improve the website. The last part has identification question.

Step 2: We asked high school students to evaluate university website. The period of collecting answers was from February to May 2017. We decided to use combination of methods – SUS questionnaire and adjusted remote evaluation. Questionnaire has online version and was distributed through online channels as emails and Facebook. We sent emails/messages to 14 high schools - directors or teachers of informatics, in region of Zilina in Slovakia. The target group for our questionnaire were high school students, who will admitting to maturity this year and want to continue at University. They are the main group of visitors to the university website.

Table 2: Number of graduating students at high schools in Zilina region in year 2017

region	Zilina
number of graduating students at high schools	6237

Total number of graduating students at high schools is 45358 in Slovakia and 6237 (Table 2) in selected region (Table 2). We chose a margin of error of 5% (Δ=0.05) and a confidence level of 95%. Then t = 1.96. ð = √ (p*(1-p)). We have to emphasize again, that we are aware that we use the calculation of the standard deviation for the alternative division. We used formula 1 to calculate representative sample size. Require sample size is: n = 177 respondents.

The questionnaire has introduction and three parts. In the introduction we introduce our study and give the main information how to fill in the questionnaire. In the first part we ask identification questions –actual school name and rate computer skills on scale 1 to 5 (beginner to expert). In the second part participants can choose one of all universities in Slovakia and evaluate its website. Adjusted remote evaluation had run as simple task. Participants were asked to find study programs on the website and if they were successful, they evaluate on the scale 1 to 5 (very easy to very difficult) how easy it was to find study programs. The last part of questionnaire contains SUS questionnaire. SUS helps us to discover the level of satisfaction of website visitors. We used the original SUS questionnaire, which consists of 10 questions with scale responses; from "strongly agree" to "strongly disagree". We only changed the word "system" to "website" in all questions. We added one open question at the end, where participants can write their own opinion of website.

5. RESULTS

The results of the study are presented in two parts according the steps of study.

Step 1: A total of 28 universities from Slovakia and 35 from Czech Republic participated in the survey. Because of postponed start of survey in Finland to the end of April 2017, the survey runs in Finland till end of August 2017. Hence, the results of Finnish part of the study are not presented in this paper.

The first part of questionnaire contains of question about how the website was created. As shown in Table 3 almost half of Slovak universities created the website internal, by own department or employee and the second half used the services from external company. Similar results have been recorded from universities in Czech Republic.

Table 3: How was the website created?

	Slovakia	Czech Republic
Internal - department/employee	46.40%	48.60%
External company	53.60%	51.40%

The next questions asked if the website has been ever evaluated, what kind of methods were used during evaluation and what were the results of evaluation. Table 4 shows that from Slovak participated universities almost 29% of websites have been evaluated and 64% have never been evaluated for usability. The 7% of participants answered they do not know this information. In Czech Republic 25.7% universities evaluate their websites for usability and 74.3% do not. The graphical view is on the Figure 1. Our expectation that: More than 90% of schools do not evaluate the usability of their web pages - has not been confirm.

Table 4: Has the website ever been evaluated for usability?

	Slovakia	Czech Republic	Expectation: 90% do not evaluate
yes	28.60%	25.70%	
no	64.30%	74.30%	< 90%
I do not know	7.10%	0%	

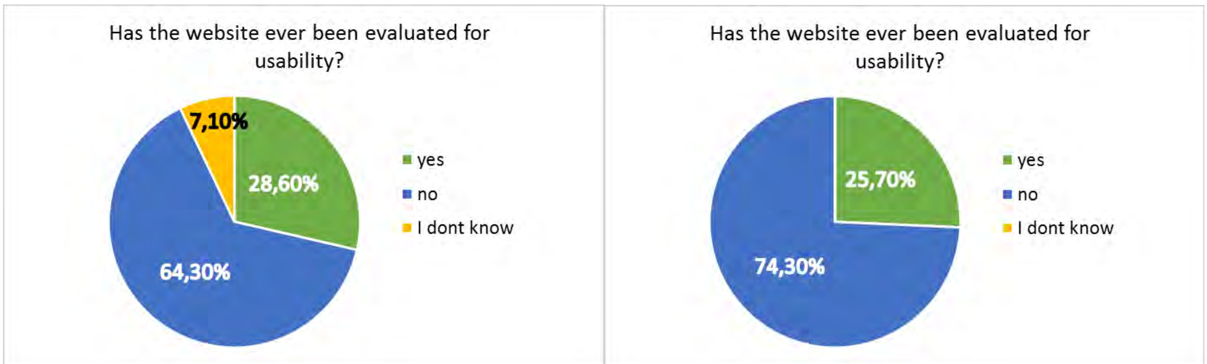

Figure 1: Usability evaluation? (Left - results from Slovakia, right - results from Czech Republic)

The most used methods were: user testing, click mapping, A/B testing, questionnaire, and 2 schools used eye tracking. During usability evaluation were found some issues: poor viewable on mobile devices; responsiveness; speed of orientation. But also a few participants answered that no issues were found during evaluation.

The third part of the questionnaire ask if they utilize data from Google Analytics (GA), if so, what kind of data and how it helped improve the website. Table 5 shows that from Slovak participated universities more than 64% utilize GA data and almost 36% do not, and from Czech Republic participated universities more 80% utilize GA data and 20% do not.

Table 5: Do you utilize data from Google Analytics?

	Slovakia	Czech Republic
yes	64.30%	80.00%
no	35.70%	20.00%

They analyse number of visitors, demographic data, locations, visitor´s behaviour, bounce rate, site search, site speed, average session duration, page views, device category and traffic. These analyses helped them: “optimize the page; the most visited pages and their data are better accessible; the structure of the information on faculty pages has been unified; helping us to design new websites for the university; the analysis of individual indicators is based on building a new portal; they confirmed the need to create a Ukrainian site mutation; based on the track used by browsers, we can determine which technologies we can and cannot use on the site; In the case of highly visited or searched pages, we improve access to them (the number of clicks from the landing page); helped to speed up page view; do a better visitors segmentation; change the content and move the most visited parts at the home page”.

Step 2: A total of 189 students responded the questionnaire. As it is presented at Figure 2 below, most of the high school students (88.9%) found study programs on the website. But there is a small group of students (11.1%), who did not find them. Also 9% of student who found study programs, later answered, it was difficult to find them.

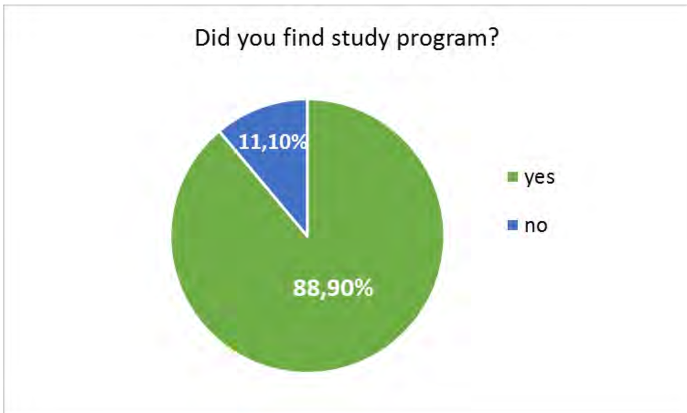

Figure 2: Successful rate of finding study programs

The second part of questionnaire was a SUS method. All participated students evaluated minimum one of all universities website, according their interest. The Figure 3 shows the results of evaluation. On line x we can see how many evaluations were done, on line y we can see average scores for all Slovak Universities - the result from SUS evaluations. According the results showed in the Figure 3 we can summarized that no website has terrible usability (25 points), 4 websites have weak usability (26-51 points – red colour), 20 websites have good usability (52-72 points – orange colour), 3 websites have above good usability (green colour), and only one has excellent usability (85 points – dark green colour). The average score in our study is 60 points, modus is 60, maximum score is 85 and minimum score is 40. The SUS score over 68 points is considered above average usability – only 6 websites have more than 68 points; and 23 websites are below 68 points what means below average.

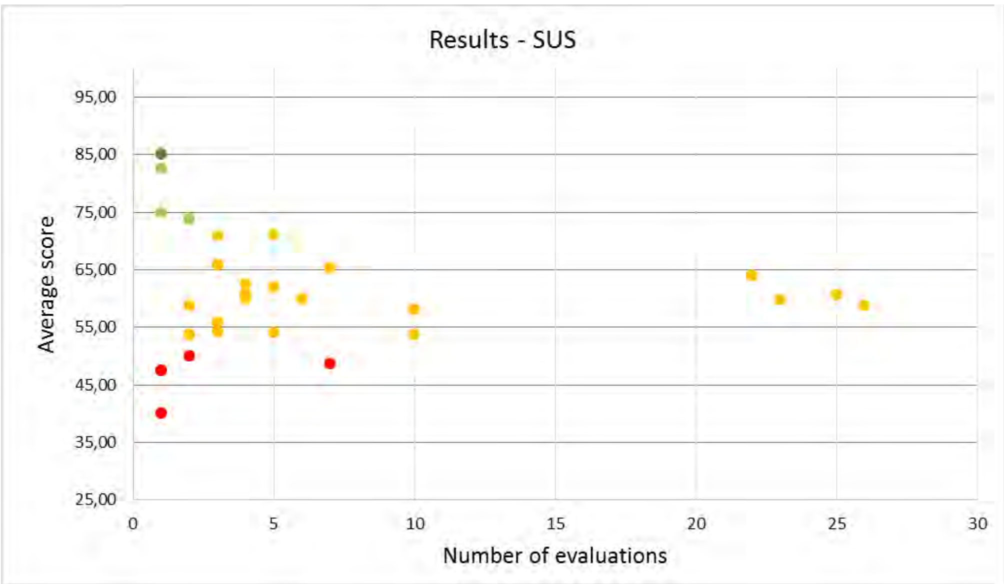

Figure 3: Results of SUS evaluations

In the last question students can write their own opinion on the website. Below are some examples of negative opinions:

“It is difficult to find basic information.” “You need to download a document with programs, unnecessarily complicated, no description of programs.” “The website design is awful, it looks like it's from 90's. IT team should really work on the website graphics.” “I don't like the squares layout. It’s confusing. I actually preferred the old website. The website also forces you to read their news, and I'm not particularly interested in that.” “I think the main problem is that there are too many information at one part. The user get lost at first.” “Information is stored in documents and not directly on the page.” “Complicated, complex, I had to read about 13 pages for my application.” “Totally good but the information is too inflated.” “So ... I did not find a study plan .... The page was unclear ... a lot of text on one side ...” “its fine ... just the font is small.” “The page is unclear. I would have to visit it more often to known it better.” “Small font, too complicated. Too much news on the main page.”

6. CONCLUSION

There are many audiences for a university website. As well as prospective students (main audience group), we may also need to cater for research collaborators, the general public, parents, alumni who might be looking at the site for different reasons. Even within the prospective student audience group there are very distinct groups with different informational needs e.g. international students, undergraduate vs postgraduate. Universities are very complex organisations and there are so many people involved who might want to publish content which does not consider the needs of the users. Academic staff may want to present their course or research in a way that is completely inaccessible for a 17 year old student trying to decide which university to go to and this can be a challenge for web team. (Kucharszyk, 2017)

Also, because a university website is so huge, we often find that people with limited web expertise are responsible for managing web content and structure for their area of the site, rather than having the whole site managed by a central web team. This can make things very inconsistent and result in an information architecture that reflects the internal structure of the organisation, rather than having information structured in a way that is logical for users (e.g. by task, or by audience).

The results of our study show current state of usability evaluations of university websites in Slovakia and Czech Republic. Only about 28% of universities websites have been evaluated for usability. More than 64% universities in Slovakia and 80% in Czech Republic utilize Google analytics data. Despite the fact that a few university administrators answered that during evaluation did not find any issues to improve, more than 11% of students did not find study programs on the website. Also it is clear from the SUS results only 6 evaluated websites have score over 68 points, what is considered above average usability, and 23 websites are below 68 points, what means below average. But it is necessary to do usability evaluations to improve the level of usability. We recommend to use combination of usability evaluation methods, and especially to ask users for their opinion, to do user testing. Many audiences for a university website means that web team has to do a lot of careful segmentation when planning evaluations and user testing, and have many personas.

7. ACKNOWLEDGEMENTS

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ACADEMIC MOBILE
An App for the student

Jordi Cuní
SIGMA AIE

Keywords
Social networking, University community, Student Information system, eLearning, Mobile App.

1. ABSTRACT

The use of the Smartphone keeps growing and university students are a key factor of this growth. According to recent studies, more than 80% of the university students have a smartphone

This figure makes the demand of services through mobile phones at the universities a reality, being these services one of the most demanded by the students.

At present, several Spanish universities already have applications and mobile solutions that develop themselves, individually supporting the costs associated both to the implementation of new services and the technological development needed for every mobile platform (iOS, Android, Windows,…). These applications are of general interest showing institutional information but there are very few applications really connected to an academic ERP to provide valuable information to the student during his/her time on the university.

ACADEMIC MOBILE was created with the mission of covering the students' needs and to be a vehicle of communication between students and university. This is an open application and easily integrated at the universities to provide valuable services to the students

1. SIGMA GESTION UNIVERSITARIA

SIGMA Gestión Universitaria [1] is a nonprofit organization established in 1996 by a group of 8 top level Spanish Public Universities to optimize their management with information technologies (IT), providing the best solutions for academic and research management. SIGMA represents 20% of the university students in Spain. The organization's goal has evolved to the continuous technological modernization of university management through the development of IT solutions. As a result, the clerical processes have been automated and their effectiveness guaranteed.

Technology and innovation are the backbone of the services and solutions provided, based on a highly open source development and deployment platform for J2EE5 certified application servers compliant on a multi-tier and high performance proven open architecture. Internationalization is also one of SIGMA's top priorities. For years, SIGMA has established relationships with other European universities consortiums. Lately, SIGMA has open new strategic areas of interest such as SaaS, BI, eLearning and Mobile.

The application should meet the following features:

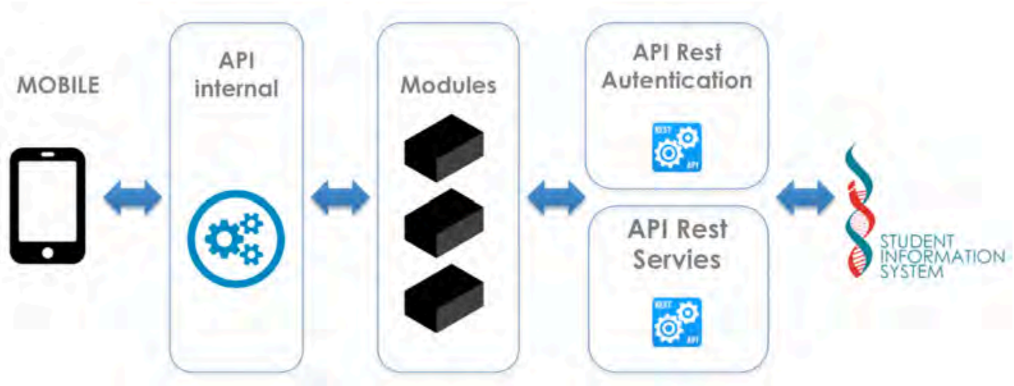
- Multilanguage
- Adaptable to the university look (logo, typography, corporative colors)
- Dynamic on the activation of services according to the App deployment level in the university.
- Open architecture to add faster non-native or third party features
- Be able of publishing on the universities' behalf
- Usage traceability
- Native development on iOS and Android
- Able to connect to several authentication systems

Main features of the APP´s design based on modular services

- Use of standard technologies.
- Centralization of common libraries for several shared services.
- Use of MVC guidelines, where every service will have its own models, views and handles.
- Dynamic menu that will allow to easily managing new entries without republishing.
- Integrate both public and private services.
- Provide services through widgets highly configurable by the student

The application is also able to receive PUSH notifications associated to the news generated from the Student Information System.

You can see below a basic diagram of the defined architecture



As shown above, the application is based on MVC to separate as much as possible the data layers from the presentation layers to facilitate the integration and launch of the App on the universities that are part of the organization.

How these layers have been designed is detailed below:

PERSISTENCE

Every service has the data needed to access through several API that return the data in JSON

Once the object is received, JSON parses the data to generate the objects related and its addition on the database, in other words, the mapping between the object received through API with its pertinent object on the database is done. All this load, parse and storage are done in a second place, so the APP doesn´t block during the loads and the user can easily navigate.

CONNECTORS (MÓDULES)

These are responsible of controlling all the logic on the APP and are also the link between the persistence layer and the (several) views so the data is updated automatically and with complete transparency for the student. There is a connector for every APP view.

VIEWS

On this last layer we have focus on the several views to be as adjusted as possible

The views have been installed considering the following requirements:

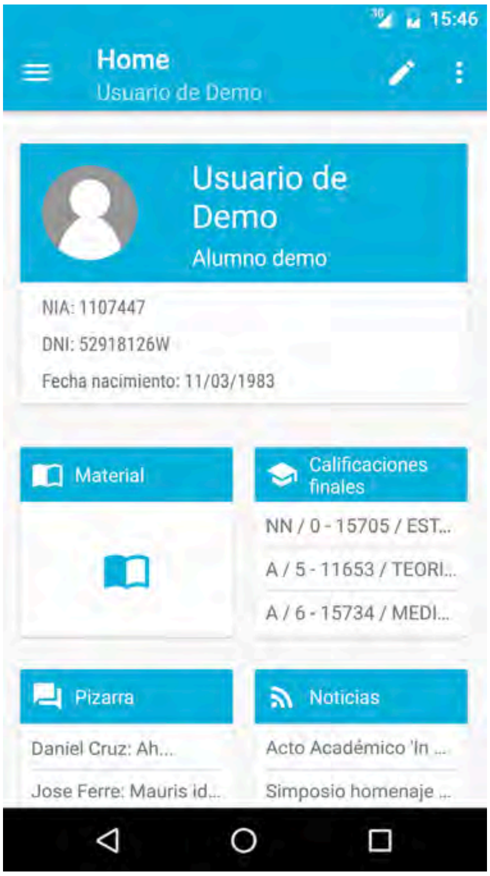
- Every text string included must be centralized, so the APP translation to other languages can be easily done.

- Responsive design regardless the device, user and platform: iOS, Android.

- On tablets the views adapt to every service for a better usage of the screen.

SERVICE CATALOGUE

The current ACADEMIC MOBILE is made of the following functional blocks with the services described below.



Institutional communication
- RSS channel

ERP university services
- My calendar
- Scholarship status
- Degree status
- My qualifications
- Registration date
- Quality survey
- Pizarra

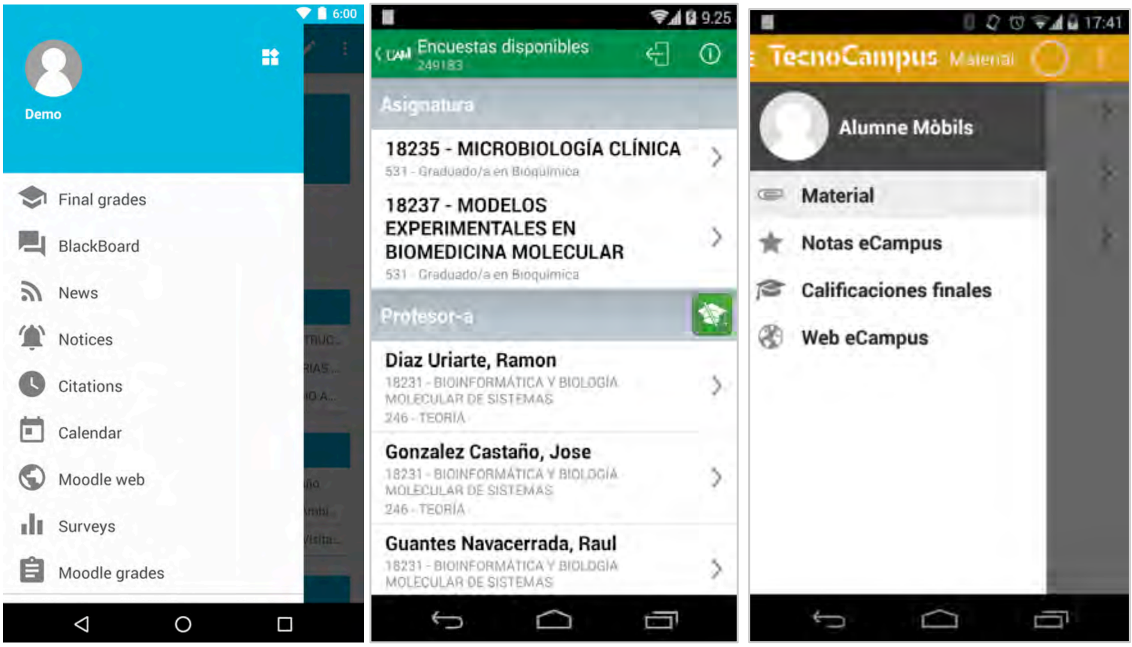
CLE services
- Integration with Moodle

Personal notifications
- Classroom change notices
- Notifications

ID university services
- My profile

On the image above can be seen that the services, apart from being part of the menu are also widgets self-configurable by the student. This is very useful to, for example, highlight the Moodle tasks registered by the teacher or outline the final mark on the subject

On the following images an example of App customization can be seen regarding the university that has implemented it.



On the three images we can see the same application with different services deployed and the specific look and feel of the 3 universities (colors, typography, logo, languages (English, Spanish and English). Even one of them using the widget overview and the other two with the hierarchical menu overview

The application can be easily adapted to every university regardless the academic management system they are using. This can be done because the application is made of modules and controlled by API data in JSON format.

2. REFERENCES

[1] **SIGMA Helping Universities Succeed** http://www.gestionuniversitariasigma.com/

AUTHORS' BIOGRAPHY

Jordi Cuní
Chief Information Officer

He was born in 1976 in Barcelona Spain. Computer Science degree at Universitat Oberta de Catalunya (2006 - 2012), Computer and Software Engineer at Universitat Autònoma de Barcelona (1997 - 2000).

He works at SIGMA since 2000, being the current Manager of the Architecture and Software quality assurance Areas. He leads a development team of 7 people for those areas.

His role focuses mainly on maintenance and develop the own Sigma framework in order to increase the productivity, define the methodology among the different areas and establish the software development tools for the rest of the company. At last but not least his area takes part on technical and performance support for our customers and helps them in the migration projects of their back-end resources. Previously, he had been project management for developing SIGMA’s area for 5 years. His main efforts was focused on develop software solutions on resource planning necessities, stock management of static and mobile resources and physical and on-line surveys.

EUNIS 2017: System level optimized planning using SAFe and Big Room Planning

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Keywords: System development, Agile, SAFe

1. Summary

In order to improve the development and release processes for the Swedish national admissions system we have introduced concepts of the SAFe framework for development with parallel teams. This has resulted in better transparency and predictability internally as well as externally.

2. Background

2.1. The Swedish Council for Higher Education (UHR)

The Swedish Council for Higher Education is a government agency whose responsibilities span across the education sector. Swedish higher education institutions has contracted us to manage admissions and to supply them with an admissions system. As a result, we possess detailed knowledge of admission regulations.

More information about UHR is available at http://www.uhr.se/sv/Information-in-English/

2.2. The NyA Admissions System

Virtually all Swedish universities and colleges uses the NyA system for admission to undergraduate courses and programs.

The process is highly automatized and practically all applications are made through the applicant user interfaces Antagning.se and Universityadmissions.se.

The system has been in operation for 12 years in 2017. Modernization has always been an issue and will especially be so the coming years as we adapt to major regulatory, administrative, environmental and technical changes. Business as usual.

3. Meeting the challenges – optimizing investments in system development

3.1. The challenge

We have been using agile system development methods for the further development of the NyA system since 2012 with very good results but by time, it has become more obvious that team priorities has diverged. In agile development, the backlog is the main planning tool and as all teams has their own there is always a synchronization problem. We needed a shared system backlog.

In 2015, the development organization consisted of six different teams of five to eight developers and with one product owner each. The team and their product owner were focused on one of a number of user categories.

The system on the other hand is still a monolithic administrative application with a single, shared, database supporting a common, complicated, business process. Obviously, the risk of inter team disturbance needs to be addressed.

The six independent teams have increased the quality of the deliveries and given a better focus on the needs of the users of the system. The downside is a tendency to sub-optimize planning on the team level; what is important for the one single user group is not necessarily most important on the system level.

Another problem was the lack of transparency and predictability for each delivery of the system; this made introduction of new releases to the business organization difficult.

We have a three-year strategic plan, updated annually, and a yearly budget for development. It has been difficult to connect these to the different team backlogs and Jira Items.

Development accounting was also a challenge as it was based on unstructured lists of maintenance and improvements.

3.2. Method

We have chosen to try parts of the Scaled Agile Framework, SAFe. System level planning requires good communication within the development organization and Big Room Planning (BRP) is a way to involve everybody.

Our goal with SAFe was to structure our planning process, which we have done by introducing:

- Programme increments consisting of three three-week sprints each
- Big Room Planning as a model for the Programme Increment planning session
- Features and Enablers, expressed as development packages in our implementation
- System demos
- Continuous integration

Goals and budgeting are expressed as a road map consisting of a list of focused initiatives. The road map also gives a context to the development and facilitates communication with stakeholders.

We have also made some organisational changes to the team/product owner structure in order to facilitate a more comprehensive view of the system.

3.3. Results and lessons learnt

SAFe concept of programme increments, feature focus and system level prioritizing has resulted in improved predictability thanks to higher transparency internally and externally. It has also resulted in a clearer structure between the development and the strategic planning.

The SAFe model is based on the presumption of product management leadership, top-down, setting goals and objectives. Our development is more bottom-up, where teams and product owners identifies business needs. We have solved this by adding a pre-planning session where product owners and team representatives agree on goals and a tentative plan for the increment.

The Big Room Planning model is efficient when applied to major changes of the business process, when there is an overall larger business need that is too big for one team to handle or when changes affect large parts of the (monolithic) system.

Major advantages with BRP includes

- Creates internal transparency, all participants gets all information
- Improves collective problem solving and builds a “we”
- Enables acceptance and a culture of commitment
- Promotes a culture of information sharing and collaboration

Release management participates in the Increment Planning process and release staff is in continuous contact with the development teams thus improving the release planning process.

All in all this has resulted in a better and more agile development planning process as well as an improved ability to release new functionality to our users.

AGILE TRANSITION WITH MORE FREQUENT DELIVERIES AND HOW THAT AFFECTS TESTING

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Keywords
Continuous delivery, Agile, Test

1. SUMMARY

One central part of transitioning to agile software development is being able to (and being allowed to) more frequent deliveries. This creates both great opportunities but also some challenges.

In the Ladok3 project, the current frequency of deliveries to production is every other week. This can be compared to the current Ladok system where new deliveries have been made four times a year.

This paper focuses on how more frequent deliveries affect the challenge of testing the system properly. It begins with a description of the concept of continuous delivery and how it affects testing, followed by an experience report on how the Ladok3 project meets this challenge, both how it has been met until now as well as challenges seen for the future.

2. INTRODUCTION

Ladok is a national student information system for higher education in Sweden, owned by 38 universities and university colleges through a consortium.

The ongoing Ladok3 project, where the next generation of Ladok is being developed, is a large agile project that uses Scrum as development method. The project consists of product owners and domain experts from many of the universities and university colleges and development teams located at Umeå University, ICT Services and Systems Development (ITS).

One big change made in the development process of the new Ladok system, within the Ladok3 project, is an increased frequency of delivery compared to the existing Ladok system that is being replaced.

3. TESTING WHEN FREQUENCY OF DELIVERY IS INCREASED

Increased frequency of delivery does impact how testing can and should be done.

3.1 CONTINUOUS DELIVERY

The concept of continuous delivery has been a central part of the agile movement ever since the Agile Manifesto was published. The first of the twelve principles behind the Agile Manifesto (2001) says:

> "Our highest priority is to satisfy the customer through early and continuous delivery of valuable software."

The main benefit from continuous delivery is the early feedback that is given by the use of implemented features in production very shortly after it is written by the developer. The possibility to fix bugs and make changes quickly based on the feedback received is also enhanced and new releases be delivered to production with very short delay.

3.2 FREQUENCY OF DELIVERIES IN LADOK

The current Ladok system that is being replaced with the new system developed within the Ladok3 project has had a delivery frequency of four times a year, with patches added when needed in case of emergency. This is what the universities and university colleges are used to. It is also a matter of accepting a new release as well as be aware of changes made in the new delivery. Striving towards more frequent deliveries does not only affect the Ladok3 project and operations but also the end users and system owners and their business. This is also a great challenge, to help the stakeholders get comfortable with more frequent deliveries.

3.3 HOW DOES MORE FREQUENT DELIVERIES AFFECT TESTING?

One major challenge when transitioning to agile development methods and more frequent deliveries is how the system can be tested. It is obvious that it does not work to have a test phase in the end of the development cycle like in a traditional waterfall project, there is just not time enough for it. The testing puzzle must be solved differently.

3.4 THE NEED FOR AUTOMATION

Making complete (manual) system tests every release is nearly impossible in every software project, but when the delivery frequency increases to every other week or higher, it is not even worth trying. One solution very popular in Agile methodologies is through increased automation of testing. This, though, must also be handled with care since creating automated test not only takes development time but also a lot of maintenance time since changes to the code affects existing tests.

3.5 THE AGILE TEST PYRAMID

Mike Cohn introduced the agile test pyramid in his book *Succeeding with Agile* (2009). The pyramid is an illustration on how test automation should be distributed between the layers of software, with more emphasis on the low (unit) level and less on the higher (e.g. user interface) levels.

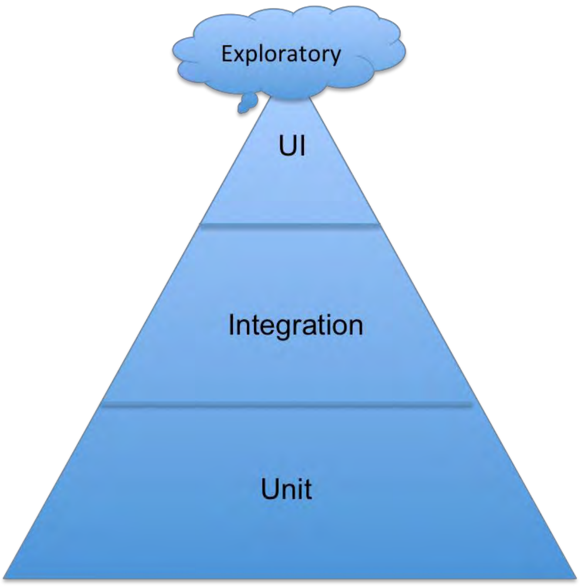

Figure 1. The test pyramid

Unit tests are the least expensive type of tests and the speed of running them is very high. Automated tests at the user interface level is much slower to run and they also cost a lot more to build and maintain. Tests on higher levels also mean increased amount of possible combinations to test which makes it very hard to keep a good test coverage. The same philosophy of test automation is also used in the concept of TDD (Test-driven development).

Manual testing is even slower but can be a good complement to the automated tests since it can add other kind of values that automated tests can’t, since human users can identify other types of issues that could possibly be problems. In the Ladok3 project, this philosophy is adopted.

3.6 EXPLORATORY TESTING AS A COMPLEMENT

With the automated tests being the testing base, the Ladok3 project uses exploratory testing as an addition in order to uncover other kinds of bugs and risks, like user experience (UX) issues.

Exploratory testing is an approach that has become increasingly popular during the last decade. Compared to the traditional scripted test methodologies, exploratory test focuses on human skill and ability to learn instead of processes. Elisabeth Hendrickson (2013) defines Exploratory testing as

> “Simultaneously designing and executing tests to learn about the system, using your insights from the last experiment to inform the next.”

In the Ladok3 project, exploratory testing is performed within the development teams, by the developers and testers included in the teams. Using Scrum as a development method, with a sprint length of two weeks, the goal is to be done with all exploratory testing necessary within the sprints, which means no test phase after a sprint is finished. This results in that the software should be possible to release at the end of every sprint.

3.7 A CHANGED MINDSET AND A LOOK INTO THE FUTURE

One of the greatest challenge when moving towards more frequent deliveries is to change the mindset, both within the project as well as all stakeholders outside the project. Agile software development with frequent deliveries requires trust and a robust system that can be released frequently with high quality. Being able to trust the code base with its automated tests together with quality built in through the development process is a prerequisite of frequent deliveries. At the same time, delivering more frequently does also mean smaller increments of software each delivery, which means less risk of breaking the software. Making the delivery process faster also means that bugs in production can be fixed much faster and a new released deployed into production.

Increasing the delivery frequency is an ongoing work with the new Ladok system, where every part of the process is being trimmed to make that possible, including the development team processes, the continuous integration environment and the operation- and deployment processes. It is also a process of helping both project member and other stakeholders get comfortable with more frequent deliveries. Perhaps in the future it will even be correct to call it continuous delivery. One major key to being able to deliver more frequently is to gain trust about the concept by delivering working software.

4. CONCLUSION

Increasing the frequency of delivery to production does affect testing a lot. It makes it more important that quality is built in during development, especially with a good base of unit tests, since the time for testing after development is decreased and of less value. At the same time, the feedback loop is shortened, making it possible to discover issues earlier and deliver fixes more rapidly. It is an ongoing challenge for the Ladok3 project to be able to deliver new software more frequently.

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6. BIOGRAPHY

Göran Kero studied Computer Science and Economy at Luleå University of Technology and holds a bachelor degree in Economy and Computer Science. He has over 15 years of work experience as a tester and software developer, first in the telecom business, Mobilaris AB and Telia Mobile, for 3 years and since 2004 at Umeå University, ICT Services and Systems Development (ITS). In recent years his primary focus has been on quality, test methodologies and software development processes, with a role as Senior Test Architect in the Ladok3 project. Göran is a regular speaker, with experience from local, national and international events, including EUNIS 2014 Congress.

Threat landscape in academic IT

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Keywords
information security, IT security, threats, cybercrime

1. ABSTRACT

In this paper we introduce you to the University of Helsinki's point of view to general threat landscape in academic IT and many of the ways we have tried to accomplish our goals in mitigating the risk posed by both the external and internal threats based on our experience of which we have drafted a list of agents countering which we consider a priority. On the technical side we describe out monitoring tools and processes. On the non-technical side, the user still remains the crucial factor in causing and preventing IT security incidents. We will brief you in our efforts in educating users in various roles and keeping the security awareness on a good level. The key to successfully design countermeasures for both new and traditional threats is to carry out systematic risk analysis regularly.

2. Introduction to IT Security management at University of Helsinki

Large part of IT environment is centralized to the Center for Information Technology (IT Center). The IT Center is organized as a separate department. It has a Board assigned by the Rector. The Center is divided into IT administration and IT services.

IT management

IT management handles the University IT sector's direction and strategy. It is run by Chief Information Officer Ilkka Siissalo. The unit is in charge of setting the IT architectures and standards, making blanket purchase agreements, managing the centralized information security services of the university and the strategic planning of the information security sector, and monitoring the development of the sector's services, volumes, and expenses.

IT services

IT services is in charge of both the centralized IT services and the IT services produced in the service centers of campus areas. It is run by IT Service Manager Eija Heiskanen. The Service Managers are in charge of their respective services. The service production is divided into four subunits:

Technology Services is responsible for maintaining the server and network infrastructure, production-related maintenance of databases, user administration systems, network services, data traffic, storage space services, technical information security and central management of workstations.

IT Solutions primarily serves the units of the university. Its duties include the support and coordination of IT system projects and acquisitions, IT center project portfolio management and application development, as well as coordination of quality work and development of operations. The subunit is also responsible for the support of teaching and research, video services, and unit communications.

Centralized Support primarily serves user customers. It is in charge of consulting services, software, and workstation services.

Local support provides close-support services at campuses and handles physical maintenance of workstations.

2.1. IT security organization

As per University of Helsinki's IT security policy (https://www.helsinki.fi/en/it/information-security/information-security/information-security-policies-and-terms/university-of-helsinki-information-security-policy), the management and monitoring of information security are incorporated into the University's general management system and are ultimately the rector's responsibility. Each head of department is responsible for the security of the systems it owns as well as for their costs and compliance with rules. The chief information officer is responsible for the main guidelines, strategic guidance and monitoring of information security as well as for the ensuring of sufficient resources for the University's central information security activities.

IT security services are organized within IT management as a team supervised by Information Security Manager Anne Hintzell. Current size of the team is four full-time persons: three specialists and the ISM. The team supports and assists departments in ensuring information security and provides information security training and internal audits. The team also provides incident handling and digital forensics services, develops security related guidelines and monitors state of information security at the University. Some of the technical security related operations such as firewall management and centralized anti-malware software are handled by respective units within the Technology Services.

Internally the team shares assignments in order to ensure everyone has at least sufficient skills in standard operations. This allows all team members to develop expertise in narrower subject matters as routine tasks do not spend all of individual's working time. Skill-wise the team's core competencies are:

- Auditing
- Data protection/privacy
- Digital forensics
- Incident handling
- Intrusion detection
- Risk management
- Vulnerability assessment

3. General threat landscape in academic IT

3.1. Evolution of threat agents

We've come a long way from 1990s and TCB who broke into 130 organizations - including University of Helsinki - just to see if he could do it. He was later caught and convicted and nowadays forges a career as a security consultant. The first half of the 2000s was still predominantly time of amateurs vying for bragging rights. It was to come to an end soon enough: The Blaster worm in August 2003 was the last non-monetized mass infection we've observed in our networks. All epidemics and most cases of external origin, starting with IRCBots in 2004, have since been driven by clear motivation to gain illicit benefit from victims' systems.

All across the spectrum adversaries' methods and tools have improved tremendously during the last 10 years. The progress has been especially fast during last couple years when intelligence agencies' tools and exploits have leaked. The current trend seems to lead towards greater equalization of tools, tactics and procedures between different agents. This both makes the lower level agents more dangerous and leads to even more severe difficulties in distinguishing agents from one another. Further propelling the advance is constantly growing turnover for cyber-crime. In global scale yearly revenues for cyber-crime groups are easily in the millions of euros, tens of millions for the more successful operators, while the whole sector reaps in billions of euros annually. Inevitably part of this money is spent on research & development of both tools and business models. Cyber-crime as a service and gamification of attacks are phenomena unlikely to go away.

For Higher Education Institutions to keep abreast of these development is problematic to say the least. Whereas the criminals can derive direct benefit from improving their processes, the defenders must incur directly increased costs and can demonstrate only indirect benefits in the form of reduced losses, notoriously hard to quantify.

3.2. Common threat agents relevant to academic IT

Although there are relatively many identified classes of threat agents not all of them are equally relevant in academic setting. In most cases Higher Education Institutions as organizations are not interesting enough to be primary targets to those agents dealing in high-value fraud or IP theft. Majority of the users are students who in general do not have much to steal besides identity.

As knowledge producers Higher Education Institutions hold copious amounts of information so ransomware could be conceived as an elevated threat but apparently it seems to target other sectors more often. As scientific research is by definition reproducible ransoming research data may not be as devastating from victims' point of view nor as lucrative from criminals' point of view. Perhaps following from this unlike many other organizations, University of Helsinki not seeing major problems with malware and essentially zero problems with ransomware. Hacktivism-related incidents are a rarity too. Presumably this is partly because University of Helsinki as an organization is politically and ideologically quite neutral, partly because many hacktivists are students themselves.

In the following chapters we will introduce the threat agents we consider to pose the highest risk factor to our IT environment. The list compiled here is based on actual incidents and to lesser degree estimates on how University of Helsinki's threat landscape could develop in the short term. One must keep in mind that these categories are not clear-cut nor universal. There are always exceptional operatives who buck the trend.

Amateurs

Amateurs are relatively indiscreet and indiscriminate with their targets. Threat-wise they do not pose serious problems to defend against and if they are successful cause mostly nuisance and mild embarrassment to administrators. Usually judicious use of firewalls and professional systems maintenance are sufficient to keep these players at bay.

Typical examples of agents in the group

- Script kiddies
- Defacers

Typical incidents

- SSH brute-force attempts
- Automated use of ready-made tools and exploits

Lower-tier cybercriminals

The bulk of all cyberattacks originates from this category of agents. Loosely bound together by motive, financial gain one way or another, they utilize nearly all attack types and vectors commonly observed. Effective defenses must be built in depth on top each other and should include both extensive technical and administrative controls. Especially important part is end-user training as many of the methods rely on social and human aspects.

Typical examples of agents in the group

- Spammers
- Phishers
- Botmasters

Typical incidents

- Drive-by downloads
- Phishing
- Emailed malware
- Automated scanning and exploitation of newly discovered vulnerabilities

Professional cyber criminals

High-level cybercriminals don't necessarily view Higher Education Institutions as primary targets. This doesn't mean Higher Education Institutions are not targeted at all. As we are soft targets with high amounts of technical resources we are useful conduits to route attacks to other organizations and in some cases researchers have financially interesting knowledge such as patentable inventions or unreleased research that may be sought after by some unscrupulous agents.

To mount effective defenses a Higher Education Institution would need highly skilled and well-financed security team and professionally designed security controls implemented in comprehensive way along with mature security awareness program along with strong support from the top management.

Examples of agents in the group

- Organized crime
- Professional hacker teams

Typical incidents

- Sophisticated phishing
- CEO scams
- Targeted hacking attacks with prior research

Insiders

In any organization the insiders are poised to inflict the worst damages. Barring a few large scale breaches it has been the insider who caused or threatened to cause the largest single damages. Human nature being what it is, it doesn't take much of a minor disagreement to escalate into open conflict unless it is dealt with immediately. What makes the situations very delicate is the fact that most often the people involved are authorized to handle the data and IT necessarily doesn't have any indication of problems before it is too late.

Defending against insider threats is a complex subject which leans heavily on administrative and management controls and leadership capabilities of those in charge. Enlisting your organization's legal department's is a very valuable tool too to enforce the administrative directives. Technical controls do not have an effect on the root causes but can reduce and in some cases prevent damage after the situation has escalated.

Examples of agents in the group

- Careless or negligent users
- Disgruntled staff or students
- Terminated employees
- Dishonest or unethical academicians

Typical incidents

- Loss of data
- Unintended publication of information
- Blackmail
- Sabotage
- Misuse of employers' assets
- Fraud

4. Risk-based IT security development

IT security development tends to rely heavily on the demand for compliance. Standards and frameworks provide an overall checklist to what tasks IT security development should consist of. At the University of Helsinki the IT security development follows the relevant legal obligations and regulations, the recommendations from VAHTI - the Government Information Security Management Board as well as good information security practices. These provide a comprehensive manuscript for IT security: f. ex. a list of things to demand from the IT providers or a checklist for IT system development. Frameworks and standards can be of best use in the centralized IT to provide a certain level of security to administrative systems. While focusing on requirements and compliance, the frameworks fail to initiate discussion on threats and risks. This discussion with data and system owners, responsible leaders as well as system administrators is a crucial part of IT security planning.

IT solutions for science and research need to be planned with the primary goal to support the key activities. Information security has to be built based on a risk evaluation rather than filling out a compliance form. In the academic world one solution rarely fits all.

5. Building awareness programs and measuring user awareness

5.1. Awareness training for staff

Regrettably awareness training for staff has been and will still for some time be a weakness for UH. There has not been a comprehensive training program nor requisite training materials. We are moving to remedy the situation but comprehensive coverage will take time. As a first phase action we have created a concise on-line course for staff and are rolling it out to IT and administrative services staff as we speak.

A distinct problem with all training is getting the audience's attention. Without putting requisite attention into understanding what the training is about the audience forgets more easily. And since an average person forgets as fast and much they do, longer-term retention rates are not very good unless engaging methods are found.

The difficulty is especially pronounced when the subjects are something people perceive as tedious, boring and irrelevant, like administrative, legal, contractual, ethical and security matters. The obvious solution is of course making the training mandatory. However especially in academic organizations such action may be viewed with disdain and many could consider it a breach of academic freedom. There is also a question of who should be exempt from the training. Again there is an obvious answer: since the matter is serious enough to warrant making it mandatory there should be literally no exemptions. Which naturally means everyone including the Rector should attend and depending on Higher Education Institution's organization the Board or equivalent external steering group too. It is sufficient to say this would be a serious test to the highest management's support.

5.2. Awareness training for students

All students must successfully demonstrate possessing necessary ICT skills by passing ICT driving license -course (https://www.helsinki.fi/en/ict-driving-licence). The course includes a chapter regarding information security and privacy protection. Security chapter introduces the basic security and privacy principles and motivates the student by walking them through basic steps to protect oneself. The course itself in worth 3 ECTS credits and has been a part of degree requirements in all faculties since 2005.

The course itself is designed to be one of the first courses a student attends to and relies heavily on self-evaluation. Students start off by acquainting themselves with the learning goals and then proceed evaluate their skills by taking five short self-assessment tests. If they score high enough they can proceed directly to exam otherwise they're steered to self-study materials and if needed to faculty-run instruction lessons.

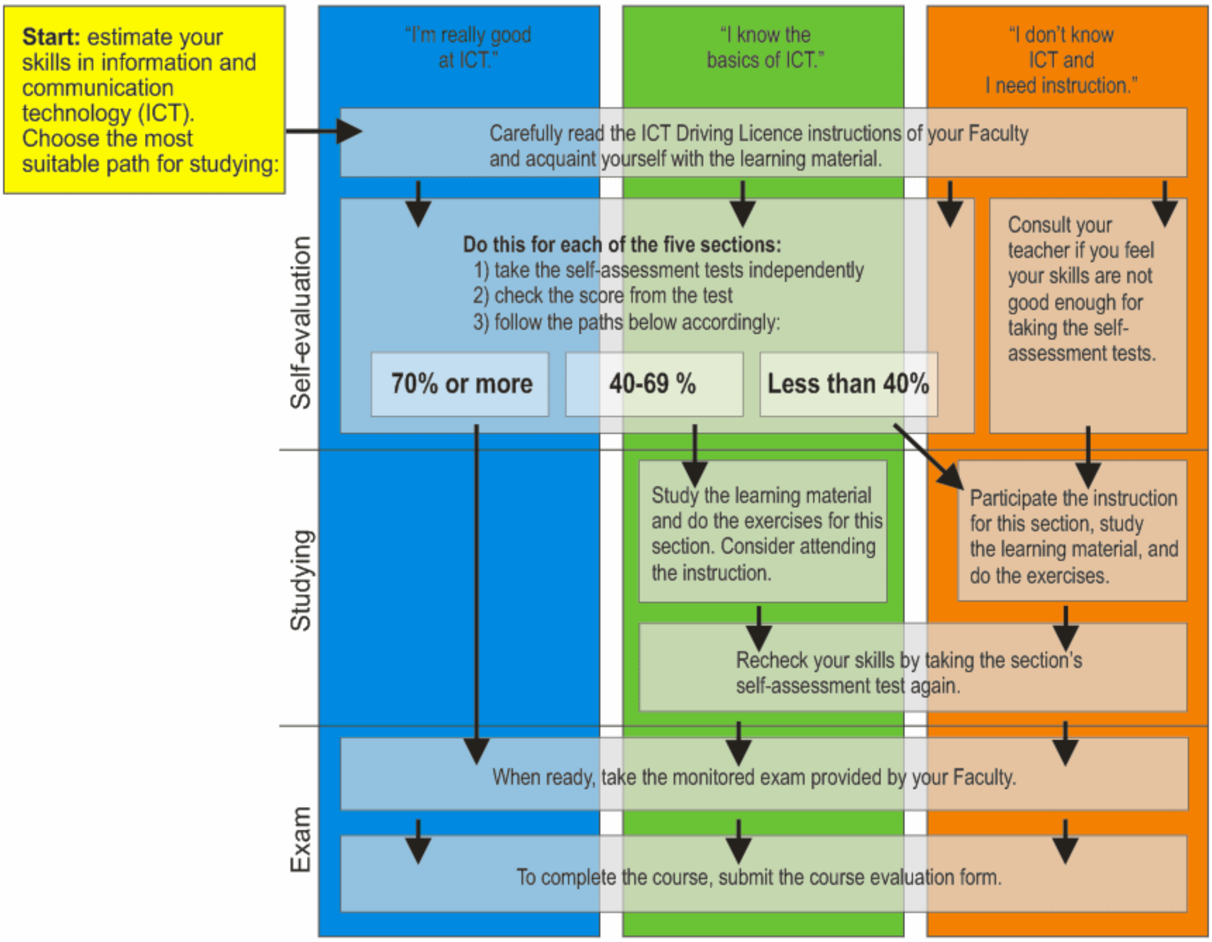

Image 1: Flow chart of the ICT Driving license course

Based on relative scarcity of security related incidents regarding students we estimate the ICT driving license largely accomplishes it's security goals by ensuring every student has at least the basic understanding of common threats and risks.

5.3. Quest for the effective awareness training

Over the years we have tried multiple methods and techniques to raise security awareness. The following chapters will introduce many of them along with our observations of their usefulness. It is hard to quantify their real effect as we have not conducted any proper research in to the matter nor have we suitable performance indicators to gauge possible changes.

Poster campaign supported by themed web pages

Of the tools we've utilized old-fashioned poster campaign has garnered the most positive feedback. Using catchy posters to direct viewers to instructional web pages about one bi-weekly changing subject seemed to resonate with both students and staff at the time. The style was deliberately chosen to be light, colorful, tongue-in-cheek even, to pique by-passers' interest. The posters were placed at or very near to buildings' main entrances to ensure maximum visibility and posters' rotation was carefully orchestrated to maintain uniformity across campuses.

Though the poster campaigns are fondly remembered the cost of running them is rather high. One needs resources that may not be easily or cheaply available such as graphical designers and copywriters and large part of the work cannot be cleanly reused elsewhere later on. Things have also moved on, nowadays posters by themselves would not be able to elicit much attention without support from corresponding social media component.

Quiz and small prizes

In one awareness campaign we ran an on-line quiz and awarded a small prize - a key lanyard - to all who completed the quiz with full score. The campaign ran for 4 months during which the quiz was taken 1834 times. It was possible to take the quiz as anonymous user, in which case the possibility of getting a prize was forfeit, or log in with university account and take a chance to win. There were 676 unique logged in users of which 436 managed to land a full score but apparently the prize wasn't worth getting as 334 of them never fetched their lanyard. Anonymous users took the quiz 732 times. Average score was 8,51 for anonymous and 8,97 for logged in users (out of 10).

Although we did not try to count unique anonymous users it was obvious that the quiz failed to reach nearly all students and staff as combined total number of the two groups was approximately 48000 at the time. Proportioning the coverage versus the required effort and monetary cost to create the quiz with prizes showed clearly that cost-benefit ratio was rather bad.

Tailor-made security training

As a part of information security team's service portfolio we create and arrange tailor-made trainings by request. Our experiences have been mostly but not universally good.

Some years ago after receiving numerous requests from individuals to run trainings on specific subjects we arranged multiple different open sessions on several campuses. Attendance was very low, below the number of requestors. It didn't seem to have an effect whether we organized the training in connection with a wider awareness campaign or as standalone events.

On-demand training requested by departments or units has proven to be far more pleasant and more useful. These events are prepared together with the requesting unit and often approach the chosen subject from their point of view. Usually the event is comprised of a lecture and a Q&A session. For more technical subjects we have most often opted for a combination of lecture and hands-on practise.

Mandatory training lectures for IT staff

University of Helsinki had to lay off staff in 2016. In these circumstances the IT management felt it was useful to remind IT personnel about administrators' responsibility and due care and diligence issues. In order to accomplish the goal the IT security team ran a series of lectures and all IT Center's employees were ordered to attend one. The 2-hour lecture consisted of walking through relevant policies, rules, regulations and laws regarding data protection, classification, proper handling and possible sanctions of improper actions.

As expected, mandatory presence was frowned upon and some employees appeared to try avoiding the lecture. The circumstances undoubtedly had a negative effect on would-be attendee's perception too. Feedback regarding the lecture's content was mostly positive though. As a part on compliance requirements set by the GDPR we're retaining the lecture and require all new IT staff to attend it. It remains to be seen whether we will require all staff to attend the lecture on yearly basis in the future.

Adopting an enterprise-like approach and requiring all University staff to attend mandatory yearly training session on subjects such as ethics, security and privacy would no doubt be a sure way to demonstrate legal compliance and improve awareness but such top-down order does not necessarily sit well with academic staff.

On-line course

Traditional instruction materials are one-way and do not have elements that would engage the reader in a meaningful way. More interactive on-line courses have proven to be effective and provide better learning results so both in attempt to heighten awareness and better respond to GDPR's requirements the newest addition to our toolkit is an on-line course.

Technically the course is deployed on Moodle and contains four main chapters with an exam at the end of each chapter.

- Information security at the University
    - Contains subchapters "Why is information security important to everyone? " and "How to work securely?"
- Data processing and classification
    - Contains subchapters "Processing different types of data" and "Storing data and cloud services"

- Office and other locations
    - o Contains subchapters "Security and information security at the workplace", "Information security of remote and mobile work", "Email security" and "Email encryption"
- Information security incidents

The IT security team collects statistics on course completion and provides corresponding supervisors information whether their subordinates have completed the course. Although the exams are graded they are provided for attendees' benefit and not used to rank people; answering all exam questions is sufficient to pass the course. This is done on purpose as the of the course's functions is to be an objective tool for self-evaluation.

At the time of writing this the course and it's English translation have been out for so little time that data regarding it's efficacy is not yet available. Pilot groups' feedback has been positive. In general the respondents have felt the contents is understandable and useful to them though some exam questions have been flagged as overly ambiguous. The first production deployment will be University Services on second quarter of 2017. This unit consists of approximately 1000 administrative staff. This should provide us with large enough sample to gauge usefulness and effect.

On the national level a number of Finnish universities have created together a generic multi-module on-line course for staff covering the most important subjects in academic IT security. University of Helsinki was not able to participate earlier but is currently considering joining in the effort.

Specific warnings during elevated threat levels or ongoing attacks

During out of the ordinary circumstances we issue targeted warnings about specific threats to groups or individuals we have determined to under elevated level of threat. Usually these warnings consist of an email sent to the targets detailing the threat and the actions they should take to mitigate it. If the target groups are large we issue a generic notification to whole university stating that we are sending out warnings to specific people and they should take it seriously. Examples of such circumstances are notable data breaches outside the University, detected malware infections often targeting certain types of devices and software vulnerabilities affecting IT services not maintained by the IT center.

Direct messaging does get the information to the recipient but it still does not guarantee it is understood nor acted upon. One notable problem with this kind of communication is the tendency of people to try and set the scary issue aside pretending it doesn't exist or trying to deny the need to do anything to protect themselves. One would be well-advised to use the expertise of professional communications staff while preparing the messages and notices sent to the recipients to verify intelligibility in adverse conditions.

5.4. Further training methods under consideration

Continually improving IT staff's security skills is vital as the adversaries' improve theirs. While advising IT administrators we've noticed their understanding of offensive hacking techniques is not always deep enough for them to consider systems' security in a comprehensive and holistic way. As hands-on exercises and gamification are effective ways to motivate people, we are considering setting up an infrastructure to host capture-the-flag -style hacking competitions. This would enable us to train IT administrators to better assess and defend their systems against malicious hacking.

The basic idea would be to let voluntary participants form an number of small teams who would then compete against each other by scoring points from different tasks ranging from quiz questions to hacking attacks in simulated environment. The platform would allow honing technical hands-on skills, teaching administrative aspects such as reporting, incident handling process and provide bridge from technical guidelines to reality.

5.5. Measuring security awareness

Currently we haven't got a good method to measure users' security awareness. Some conjecture can be gleaned from incident statistics and types of tickets opened with IT security team but precise this information is not. In the future the on-line course will provide statistical data on coverage and relative skill level. Likewise the students' ICT driving license provides its own statistics but both courses lack indicators on how well people are able to apply the things they learned.

Many IT security consultancies provide different services to measure the organizations security posture and awareness in real world. One feature we have considered is measuring our user's resiliency against phishing by authorizing and contracting a consultancy to conduct life-like phishing attacks against our users. By targeting statistically significant sample we should be able to gain far more precise data on how and what kind of phishing fools the users. This would allow us to identify what specific areas we would need to improve in awareness training.

6. Monitoring and auditing IT environment

6.1. Environment sections

The current IT environment of the university of Helsinki is large and heterogenous. It consists of different tiered systems. They come with varying threats, and managing it requires constant monitoring and auditing to be able to assess the current security level and to react to newly found weaknesses.

Network infrastructure

Providing the physical layer of access to data. This means firewalls, routers, network switches, wireless access points. Our network teams handle network planning, management and monitoring mainly focusing on the usage levels and providing sufficient bandwidth to users. Any anomalies in usage levels can be monitored and detected.

- Netflow data is gathered for statistical analysis and for forensic use
- Network firewalls gather statistics on possible DDOS attacks, intrusion attempts
- Bandwidth usage is monitored

Server instances

These vary from physical rack servers to virtual servers, most managed by our server management teams, not forgetting cloud-based services (SaaS), Both Linux and Windows servers are numerous and tend to be very highly standardized. Some specialized server instances are jointly managed by our teams (The base OS) and external consultants (Applications) while some are completely external (Cloud-based computing).

Server teams rely on automated checks and keep the server and virtualization infrastructure up to date. Some security-related logs are centrally collected. Server managers have access to and are encouraged to use our vulnerability scanner to check the systems they are responsible for.

Workstations

The vast majority of workstations 0are running standardized Microsoft Windows. There are also a lot of OS X computers and Linux computing, predominantly in our hard sciences units. All employee computers are centrally managed, and come with our own security customizations.

Local firewalls and antiviral software forward alerts to a central management system. Workstation operating system and application installations and updates are centrally managed and monitored. User data is mostly stored on proper storage infrastructure.

BYOD

There are workstations that are owned and maintained by their owners. We have no control on these devices, and we provide our users with suggestions and guidelines on how they can be used. Because of their nature and inherent risks, BYOD devices are only allowed on the wi-fi networks or ethernet networks with similar access restrictions.

Other devices

IoT in building automation, classroom AV equipment etc. A real can of worms. This is a problematic area, as these devices are often purchased by the building administration office and are can be either very old or sometimes not designed with any network security implications in mind. Network scanning can also disturb the proper working of these devices. They are isolated from production networks as much as possible.

6.2. IT Security team's tools

The IT security team employs automated network vulnerability scanning and compliancy checks:

- Discovery scanning for new devices that have appeared on the local network, and those that are exposed to the internet
- Scanning for open ports and services
- Identifying the services and software versions in use
- Probing for known vulnerabilities
- Alerts and statistics

These checks are automated and recurring. This gives us historical perspective on the vulnerabilities a system may have.

Intrusion Detection System

A smaller subset of servers and workstation networks that deal with more sensitive data are subject to more scrutiny.

All IP packets are inspected, and possible intrusion attempts cause alerts. Suspicious traffic is stored and can be examined later if needed for forensic study.

Honeypots

As network monitoring is typically router-based, computers on the same LAN subnet can communicate between each other without being detected. Only the local firewalls on servers and workstations report such traffic.

To gather intelligence and situation awareness in our visitor and BYOD networks, we're employing honeypots. These are Linux servers with software that answer on all ports and even try to mimic real-life server software. All traffic is logged and reported, and presented on a dashboard that provides a quick view of the situation and how the possible threat levels are changing. We typically can see misconfigured devices and port scanning attempts in these networks.

Penetration testing

New services are penetration tested before they are taken into production use. Depending on the data sensitivity level and total threat assessment, testing can be done in-house or using external consulting firms.

Work to be done:

In order to maintain compliance with GDPR, some form of SIEM system should be implemented to maintain a complete overview and to allow for quicker reaction time to events.

7. AUTHORS' BIOGRAPHIES

Anne Hintzell is the Information security manager of University of Helsinki. Anne holds an M.Sc degree in computer science and a CISSP certification (ISC^2). Anne has worked in the IT field since 2004, focusing mainly on IT security and enterprise architecture.

Kenneth Kahri is an IT security specialist at the University of Helsinki. He has worked with academic IT since 2002 and in IT security since 2004. As a member of University's CSIRT team he has been considerably involved with incident handling and digital forensics.

Tero Kärkkäinen is an IT security specialist at the University of Helsinki. He has a background in server and network management, having run the UH video management systems and network operations for 16 years. Tero is now using his experience to the benefit of the CSIRT team, handling technical aspects of threat assessment and mitigation.

Using git for configuration management and secured centralized deployment

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1. ABSTRACT

This article explains a best practice approach to configure, deploy and operate the web-based campus IT system HISinOne in a heterogeneous server environment by means of distributed version and configuration control, and a centralized software repository, using common tools, such as git and ssh.

2. THE CAMPUS IT SYSTEM HISINONE

HISinOne is a web-based student lifecycle management IT system with many installations in Germany (www.hisinone.de). The system covers the complete student life cycle. It is mainly programmed in Java with parts written in Ruby and runs as a Tomcat-based Java8 web application. The development of HISinOne is centrally governed by HIS eG, a registered cooperative society, in which a majority of German HEIs are represented as members. Each HEI operating HISinOne must configure and scale the IT system to its particular needs. While some part of the configuration settings are exclusively stored in a central database, other configuration parameters are stored in configuration files. In addition, the software supports so called extensions, which allows customers to create their own java extensions using an API. In larger HEIs, the software is usually operated in a server cluster for reasons of load-balancing and to implement dedicated subclusters with limited role-based access by configuring a minimized set of roles with access rights in these logical subclusters.

In small scaled environments (i.e. without logical subclustering), the software can be operated mostly with a set of built-in configuration management tools. However, more individualized, complex and security-aware operation scenarios require specialized machine-related configuration settings in the configuration files. Furthermore, changes in a server cluster exceeding a dozen of servers cannot be applied manually for reasons of system integrity.

The University of Duisburg-Essen was one of the first HEIs to rollout HISinOne for student management as described by Biella et al. (2012, 2013). The software is operated in a testing, staging and production environment. In terms of a software configuration management workflow, we want to highlight a best practice approach focusing on version and configuration control, collaboration support, branching, and deployment.

3. VERSION AND CONFIGURATION CONTROL

Software version control is usually applied in software development to uniquely identify the state of a software product within a development cycle. If applied to a software that already went through a vendor's QA development cycle and only lacks customer-specific configurations, the process is rather called configuration control. As HISinOne is a web application, we use git as the software version control system with a centralized server-based repository. There are four layers of data that can be identified and that need to be clearly separated and organized in this customer-specific configuration process: the software distributed "as-is" by the vendor (layer 1), file-based changes that overwrite this data (layer 2), files that extend the existing code base, i.e. customer-specific configurations or java extensions (layer3), and individual server-related files (layer 4). All files from layers 1 to 4 define a configured clustered versioned state of HISinOne for the repository. All states, i.e. commits, are kept in the central repository, by which fast and tracable rollbacks are facilitated, especially when handling a large number of changed files.

4. COLLABORATION

Due to the layered structure, modifications by multiple experts in a distributed software version system require documentation and communication skills to keep merging efforts and issue handling at a minimum. It is crucial to establish an awareness for documentation. Commenting commits has helped to improve the change documentation and allows the system administrators to easily track the changes committed by co-workers in a collaborative environment.

5. BRANCHING

Branching is a mechanism for creating a new version instance within the git repository. The creation of a separate branch in configuration control is usually triggered by a new major software release or a software patch distributed by the vendor (i.e. changes in layer 1), changes in the HEI's configuration or extensions (layers 2 or 3), or changes in the server-related configuration (layer 4). In all cases, the code integrity of the layered structure of layers 1 to 4 must be re-established accordingly with all customer-specific requirements, in a process called "merging". Merging can be challenging in layer 2 as there may exist up to three mutually different versions of a file that have to be merged into one new file ("cherry-picking process"). In layers 3 and 4, customer-specific settings have to be merged and cross-checked with regard to the latest configuration specifications by the vendor. Finally, the "new" branch can be used to deploy a new testing environment and an iterative test scenario can be initiated. Once tested, approved and staged, the branch becomes the new "master" or production branch and can be deployed to the production environment.

6. DEPLOYMENT

The deployment of a web application running in a Tomcat server cluster implies that a pre-defined set of files (i.e. the approved commit) is copied to a dedicated folder on each application server. Although git is a versioning tool following a distributed development paradigm, we use a centralised git repository server for deployment. The repository contains a very small set of files, which is individual to each application server and, hence, excluded from the automated distribution. These server-specific files do not change very often and are copied manually, if required. Logical subclustering is basically implemented using these individual configuration files by shaping a servers "task" within the cluster using a server-specific HISinOne module configuration and their corresponding role-based access restrictions only.

The general deployment workflow for a production server environment starts with a local git checkout on the central git repo server using the master branch. When finished, ssh connections are opened to each web application target server, which trigger a remote script execution on each server. The remote script synchronizes the contents in the "webapps" folder using rsync via a secured connection, with minimal set of local rights and with regard to the exclusion list specified in order to keep the individual layer 4 files unchanged.

7. SUMMARY AND OUTLOOK

The configuration management and deployment best practice described here, has been successfully used for more than one year. It is planned to add more parameters to the deployment shell scripts, such as an individual "exclude file list" and the branch name. We also consider the use of gitlab.

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9. AUTHORS' BIOGRAPHIES

Dr Daniel Biella is working for the Centre of Information and Media services at the University of Duisburg-Essen (UDE). He is responsible for the IT operation of the campus and resource management systems (ZIM-CR), including HISinOne and SAP among others. He also works in various projects that involve web-based information systems and XML-based metadata standards. In addition, he has been working as lecturer in information visualization and web-based 3D learning museums.

M.Sc. Sven Radermacher is working for the Centre of Information and Media services at the University of Duisburg-Essen (UDE) as team leader campus management (CM) in the ZIM-CR department. He has been working with IT systems for 13 years and was one of UDE's IT system administrators piloting the software HISinOne in 2009.

B.Sc. Jörg Mathieu is working as IT system administrator for the Centre of Information and Media services at the University of Duisburg-Essen (UDE), in the ZIM-CR department. In addition to system configuration, his focus is on the security infrastructure of the CM system HISinOne, including topics like reverse proxying, secure deployment techniques, and firewalls.

The Campuscard Advanced: Integration of Future Electronic Solutions into Student and Employee Cards

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Keywords
Smartcards, Mifare, Electronic Services

The Campuscard system is an innovative, integrated card system for universities and colleges, which is introduced as joint project of six universities and colleges in Berlin. The system is designed to incorporate multiple card types, from student cards, which are being currently introduced at the six institutions, to employee and visitor cards, with multiple services included.
The system is based on Mifare DESfire EV1 cards and is compliant with ISO/IEC 14443 (NXP Semiconductors N.V., 2010). This signifies that the security of the cards is on par with other comparable card based solutions. (Oswald & Paar, 2011)

The Campuscard Alliance makes it possible for HEIs to introduce a novel approach to card systems by creating an innovative solution and infrastructure not only to solve the problem of issuing 150 000 cards, but also for the first time, create system wide services for the students and employees. (Molnar, 2016) The successful introduction of the first generation cards makes it possible to start a project with a vision for the future of the Campuscard system, which will not only enable system wide services, but also offer higher application security and system wide compatibility.

Our current cards integrate four functions, which present the users the standard set of services most universities and colleges offer. These include the optical identification, the electronic payment system for the canteens, cafeterias, copy and print services, the use of the libraries with a barcode and an optical ticket for public transport.

The first supplemental function will be the introduction of an RFID based identification in the libraries, which will replace the often-problematic printed barcodes on the card. The implementation of this feature is currently in progress and will be available for the users in late Q2 2017.

The cost effective integration of this feature into an established and complex library system is not obvious and requires an innovative approach. Libraries of the six participating HEIs use various types of self-services kiosks, which have to retrofitted with a RFID reader if possible without any modification of the software of the kiosk itself, as this would not only cause considerable costs but could also impair the system stability. Our solution for this problem is the integration of the decoding and reader logic into a smart RFID reader, which is connected to the computer in the kiosk via USB and emulates the barcode reader. The computer receives identical input from both sources and does not need any modification in the software, as both devices input the library ID through the keyboard buffer.

The cards can be coded with the library ID at our validation kiosks, which are used by the students every semester to revalidate the validity of the cards. This enables a seamless integration of the new identification system within just one semester without the need to issue new cards to existing users.
The incorporation of the electronic library ID makes it also for the first time possible to offer a system wide library use for the users with their Campuscard, eliminating the need for registration at every new library. We strive to introduce this feature by end of 2017 for our student and employee cards.

We are also developing a method to introduce a compatibility between the Campuscard System and the VDV e-Ticket. (VDV, 2014) This will not only enable our users an easier and faster contact-less validation process, but also enhance the security of the ticket component of the cards. As the current ticket system is only optical, the electronic implementation will enable a decisively faster reaction time for the authentication of the ticket validity for both the transport providers and the HEIs.
The structure of the VDV e-Ticket requires the use of SmartMX card technology, which will require us to create a system based on these cards with a Mifare DesFire EV1 emulation besides the e-Ticket application. This raises the technological barrier of the project and requires further research into the implementation. We plan therefore to launch the first cards with an integrated e-Ticket in 2018 or 2019.

The integration of these functions in addition to the innovative card issuing process already in use will create a highly advanced card systems for the universities and colleges in Berlin. The open and modular design of the system will also the possibility for other institutions to introduce the Campuscard.

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Author´s Biography

Dr. Tamas Molnar is the head of unit of the Service Centre Campuscard since 2015 and project manager for the Campus card system since 2011.

Education

Primary and Secondary Schooling – Some in Germany
2001 Completed with Final Examination

09/2001 – 07/2003 University of Technology Budapest – Studies: Electrical Engineering

09/2003 – 07/2008 Corvinus University Budapest – Studies: Business Information Systems
Focus: Electronic Government

2007 - 2008 University Potsdam, Exchange Student Informatics

2008 Degree Business Informatics (Grade: Good)
In cooperation of the University Potsdam and the Corvinus University Budapest

05/2009 - 04/2014 Humboldt-University Berlin – Ph.D. Program
Focus: Software Usability in Electronic Government Systems

2014 Ph.D. in Software Usability (Grade: Magna Cum Laude)

Work Experience

09/2005 – 01/2006 Teaching Assistant, Corvinus University,
Chair of Theoretical Informatics, Focus: Oracle Database Systems

09/2006 – 10/2007 Project Team Member, Auda GmbH.
Focus: Multimedia Systems in education

10/2007 – 03/2008 Work on the Usability Project of the State Chancellery Brandenburg

01/2009 – 10/2010 Consultant/Project Lead, Brandenburg State Forestry Institute
Focus: IT-Security Projects

Since 01/2011 Project Manager, Humboldt-University Berlin
Focus: Smartcard based identification systems

Since 06/2015 Head of unit, Service Centre Campuscard, Humboldt-University Berlin

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Achieving a trust relationship model in eduroam - the case of an RadSec pilot implementation in Portuguese Higher Education Institutions

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Keywords
Eduroam, security, trust, hierarchy, Radius, RadSec, mobility, DNS.

1. ABSTRACT

Eduroam or Education Roaming, is a RADIUS-based (Remote Authentication Dial In User Service) infrastructure that uses 802.1X security technology to allow for inter-institutional roaming.
Since its origin in 2002, eduroam has rapidly spread across the world and now students and researchers from over 85 countries can benefit from free, secure and reliable wifi access. Making this initiative probably the major success story for Research and Education mobility in the past few years.
Being part of eduroam, allows users visiting another member institution to log on to the WLAN using the same set of credentials (username/password) that the user would use if he were at his home institution. All this with a minimum administrative overhead.
The current RADIUS hierarchy protocol implementation of eduroam works well. However, due to the constantly growing number of users and organizations around the world, issues related to timing, security and reliability of communication started to appear. The goal of a RadSec is to handle these issues, add features and more management flexibility.
The current paper intents to describe and report of a Portuguese RadSec pilot implementation between the FCCN - a branch of FCT – the Portuguese Foundation for Science and Technology, with the aim of planning and managing the RCTS – the Science, Technology, and Society Network, UTAD – University of Trás-os-Montes and Alto Douro, IPCB- Polytechnic Institute of Castelo Branco and ISCTE-IUL University of Lisbon. Each of these institutions implemented different technological approaches in order to enable a heterogenic multi-domain RadSec infrastructure aiming to enable a good practice approach to a wither national implementation.

2. EDUROAM AND AUTHENTICATION INFRASTRUCTURE

Eduroam or Education Roaming, is a RADIUS-based infrastructure that uses 802.1X security technology to allow for inter-institutional roaming. Being part of eduroam, allows users visiting another member institution to log on to the WLAN using the same set of credentials (username/password) that the user would use if he were at his home institution. All this with a minimum administrative overhead (Belnet Eduroam.be website, 2011).

Eduroam supports over 5 million access authentications every day with over 500,000 international authentications daily. Eduroam is truly supporting the vision of a global village for Research and Education. Only in 2016, eduroam expanded with a 23% increase in international authentications and a 26% increase in national authentications. Now 86 countries now take part in eduroam around the world with Tajikistan being the latest country to join the eduroam (Figure 1) (Eduroam.org website).

Figure 1 – Worldwide eduroam distribution (source https://eduroam.org).

In total, the eduroam Authentications systems recorded over 2.6 billion national authentications (where users from another institution in the same country authenticate their WiFi access via eduroam) and more than 592 million international authentications (Eduroam.org website).

In Portugal, eduroam is present in 61 Higher Education Institutions scattered all over the the country and also with external coverage outside of the campus environment. In some cities, public parks, libraries and museums, are also covered.

In 2006, the Portuguese eduroam network was initially designated as the e-U network. The e-U network was created under the e-U Virtual Campus initiative, a project partially funded by the Portuguese government through the Program of Action for the Knowledge Society (POSC), coordinated by the Agency For the Knowledge Society (UMIC) and developed and maintained technically by the Foundation for National Scientific Computation (FCCN). The e-U “Campus Virtual” initiative aimed to increase the online access to researchers and students also to promote the online presence of academic contents, which sought to encourage and facilitate the production, access and sharing of scientific Knowledge (Eduroam.pt website, 2015).

Also in 2006, the e-U network was the third, and long-standing, largest national university network to join the European mobility network eduroam. With the emergence of the eduroam brand at the European level, security updates and other configurations were carried out in order to fully comply with the European mobility service (Eduroam.pt website, 2015).

Eduroam is based on 802.1X and a linked hierarchy of RADIUS servers containing users’ data (usernames and passwords).

Participating institutions must have operating RADIUS infrastructure and agree to the terms of use.

802.1X is an IEEE Standard for port-based Network Access Control and provides an authentication mechanism to devices wishing to attach to a LAN (local area network) or Wireless LAN.
RADIUS which stands for "Remote Authentication Dial In User Service", is a network protocol which controls user network access that serves three primary functions:

- Authenticates users or devices before allowing them access to a network;
- Authorizes those users or devices for specific network services;
- Accounts for the usage of those services.

The RADIUS protocol is generally hidden inside of the management core of the networks, and is not seen directly by end users. i.e. it is run between trusted systems in the network.
The simplicity, efficiency, and usability of the RADIUS system led to its widespread adoption by network equipment vendors, to the extent that currently, RADIUS is considered an industry standard and is also positioned to become an Internet Engineering Task Force (IETF) standard (Network Radius Website).
The RADIUS client-server protocol has advantages, some of them including (Network Radius Website):

- An open and scalable solution;
- Broad support by a large vendor base;
- Easy modification;
- Separation of security and communication processes;
- Adaptable to most security systems;
- Workable with any client device that supports the protocol;
- Very simple client implementation, usually only a few hundred lines of code;

In eduroam implementation, the RADIUS hierarchy (Figure 2) forwards users credentials securely to the users' home institutions, where they are verified and validated. To protect the privacy of the traffic from the user's device over the wireless network, the latest up-to-date data encryption standards are used. The user's home institution is responsible for maintaining and monitoring user information, even when the user is at a guest campus. Thus, this data is not shared with other connected institutions (Eduroam.org website).

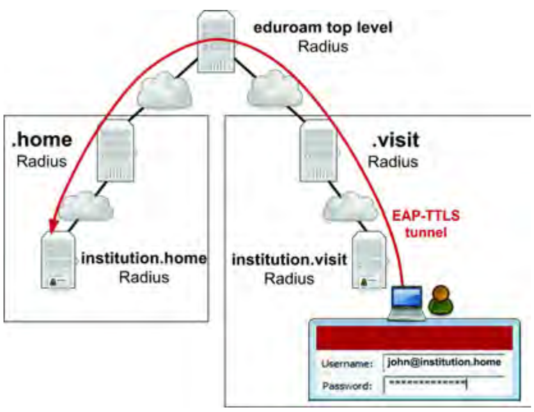

Figure 2 – 802.1X Radius architecture (source: eduroam.org).

As already stated, one of the fundamental bases of the eduroam is the high security standards that are applied and the confidentiality of the users' data. This is done using the most modern protocols of authentication and data transmission. Thus, there is a constant need to improve and maintain in a state of the art all the authentication mechanisms of the eduroam network, ensuring the best possible levels of security in the network and its use. This means that it is necessary to carry out periodic updates in the infrastructure.
The higher incidence of these updates had been centred on the mechanisms and protocols of communication between access points and users' equipment, since these are the most vulnerable points and with a lower degree of control on the entire authentication process.
Most of the authentication and authorization mechanisms currently in use on the eduroam network are based on the RADIUS protocol. This protocol has identified some limitations that may contribute to the emergence of problems in maintaining its use.
One of the biggest problems in data transmission between Radius servers is in the communication protocol used, UDP. This protocol does not use any transmission control mechanisms, which means that in authentication processes that pass through several Radius servers, packets can be lost and they are not forwarded. This loss of data impairs the authentication process, forcing it to be repeated, which generates unnecessary traffic on the network and, in certain situations, the passage of large volumes of data in the eduroam authentication structure (RadSeC WhitePaper).
Second, the data in conventional RADIUS access requests is mostly plaintext, including the user name, IP address, login times and other data. The user’s password is encrypted with a shared secret, but using a fairly weak encryption algorithm. This means that eavesdroppers can gain valuable information by listening in on conventional RADIUS requests. This is not usually a problem where the RADIUS requests travel over an otherwise secure or private network, but it is a security problem when the RADIUS requests travel across the internet or any other insecure or shared network (RadSeC WhitePaper).
Furthermore, conventional RADIUS uses the unreliable User Datagram Protocol (UDP) for transport. UDP does not guarantee to deliver messages. The RADIUS protocol permits a limited number of retransmissions, but it does not guarantee the delivery of requests. Therefore, conventional RADIUS requests can sometimes be lost or dropped, especially on a congested network. This can cause inconvenience for users trying to log in, and lost accounting messages can mean lost income for operators (RadSeC WhitePaper).
Other problem that should be pinpointed is that the RADIUS protocol does not always provide a reliable indication of whether the RADIUS server where you are connected to is the one that it should be expected, or that the client that sends a request is really who it he claims to be. This means that it is relatively easy to spoof RADIUS clients and servers when using conventional UDP based RADIUS proxying. This can be used by attackers to gain valuable information about an operator’s network and users.
To overcome these problems, RadSec was developed. RadSec stands for Secure RADIUS protocol. This is a protocol which implements the radius protocol on top of TLDv3 transport layer as defined in the ietf draft “draft-ietf-radext-radSec-12” and is a protocol for transmitting Radius authentication and authorization data natively based on the use of TCP and TLS.
The main advantages of the RadSec protocol are as follows (Figure 3):

- TCP - Guarantee of control mechanisms of data transmission;
- TLS - Ensuring inter-server communication security;

- The use of these two methods gives Radius more reliable transport mechanisms with data transmission control while adding to this process an additional layer of data transmission security between Radius servers.

The TCP protocol guarantees the existence of control mechanisms in the data transmitted between the different servers of Radius involved in an authentication process and in case of failure to deliver a package to a certain server, it is resent, avoiding the repetition of the whole process of authentication.
The use of TLS and server certificates, based on a single authorized CA, ensures authenticity and security in the communication process between RADIUS servers.
In RadSec the introduction of TLS also allows direct communication between Radius servers through the use of Domain Name System (DNS) mechanisms, guaranteeing an optimization of the entire authentication process.
The process of discovering the authentication servers relies on DNS mechanisms that provide, via SRV registers, the name/IP of their server.
RadSec as an hierarchical model provides a good trust relationship between each participant. With RadSec you need to transmit digital certificates between RADIUS servers. Also, the digital certificates need to be conform with a certificate policy.

Radius UDP implementation RadSec TCP and TLS implementation

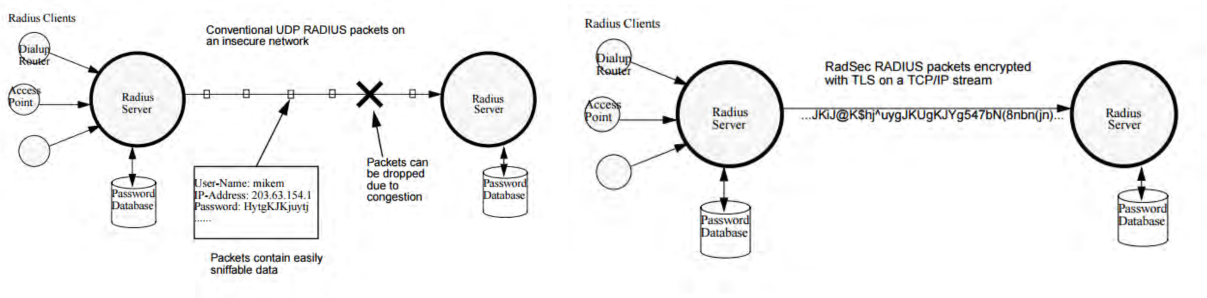

Figure 3 – Radius Vs RadSec security (source RadSec White paper)

3. THE INVOLVED INSTITUTIONS

FCCN is a branch of FCT – the Foundation for Science and Technology, with the aim of planning and managing the RCTS – the Science, Technology, and Society Network (FCCN Website), a digital research infrastructure covering all areas of knowledge, offering national education and research institutions a set of advanced digital services that allows them to work on national projects and also to integrate with or access international research projects and resources.
This ability to access international content is provided through the European network GÉANT, which interconnects with and provides advanced digital services to the European networks for national education and research, of which the FCCN is a National member.
The role of FCCN in the eduroam infrastructure is to operate a Federation Level RADIUS (FLR). It manages and maintain the national radius proxy infrastructure, being a peering point

between the different Portuguese eduroam institutions and also provide an uplink from the federation to all other eduroam federations.
On the traditional Radius model these Federation Level RADIUS servers receives the authentication and accounting request from the different roaming users, forwarding them to the home institutions, and also manages the answers from that servers.

At the University of Trás-os-Montes and Alto Douro (UTAD Website), the 802.1X/eduroam infrastructure is based on Cisco APs (220 aprox.) and Meru Access Points (50 aprox.). The authentication service is provided by an open-source FreeRADIUS implementation, with dynamic Vlan assignment, is connected to a central LDAP server for the authentication processes, and using MySQL and Mongo DB for accountability proposes.

At ISCTE-IUL (ISCTE-UIL Website)University, the 802.1X/eduroam infrastructure is based on 225 Meru/Fortinet Access Points, working in with 802.11n on the 2.4GHz band and 802.11ac on the 5GHz band. The models used are mainly the AP1020 and AP832i.
The authentication service is provided by a in-house customised open-source FreeRadius since 2013.
The current FreeRADIUS implementation is:

- a 3.0.x version in a Debian 8 server active master, and a 3.1.x version a Debian 9 stand-by slave;
- connected to the Active Directory services for authentication and user VLAN selection;
- supporting the PEAP-MSCHAPv2 and EAP-TTLS-MSCHAPv2 for client authentication;
- using a MySQL DB for authentication logging and accounting purposes;
- monitored by the NAGIOS platform;
- directly connected to the PT eduroam federation since 2005;
- sending statistics/logs for the PT federation.

The IPCB (IPCB Website) is a public higher education institution with administrative, scientific and pedagogical autonomy. Its mission is to give citizens a high standard of qualification, the production and dissemination of knowledge, as well as the cultural, artistic, technological and scientific teaching of its students in an international frame of reference.
The 802.1X/eduroam infrastructure in IPCB is composed of 125 Extreme Networks (formerly Enterasys Networks) access points connected to two virtualized wireless controllers making that in the radius server point of view appears only one access point. For authentication and authorization and accounting IPCB uses Radiator (https://www.open.com.au/radiator/) service and user credentials are provided by a central OpenLDAP Server.

4. THE PILOT IMPLEMENTATION

Taking into concern the demonstrated issues related to security, efficiency and manageability that the implementation of RadSec can drive from the success of eduroam, the Portuguese NREN jointly with 3 Higher Education institutions (UTAD; IPCB and ISCTE), started a pilot project aiming to implement RadSec in the eduroam authentication infrastructure.
All of these institutions have different infrastructures and RADIUS authentication methodologies or roles in the national RADIUS federation.

On the new RadSec model, the Federation Level RADIUS servers will act only as a backup connection to the different institutional eduroam radius servers. The communication between these servers will still be made using RadSec.
If the destination institution is still in the traditional Radius model, then the Federation Level RADIUS servers will communicate using the old protocol, acting as a dual stack server. It can also act as a RadSec endpoint if any institution don't want to use RadSec, using just the DNS dynamic discovery.
The implemented pilot, also permitted a seamless evolution to RadSec without any disruption to users in manner that the original radius implementation stayed as backup and redundancy.

Figure 4 shows the evolution made for the RadSec Proxy implementation in the institutions.

Before RadSec **After RadSeC**

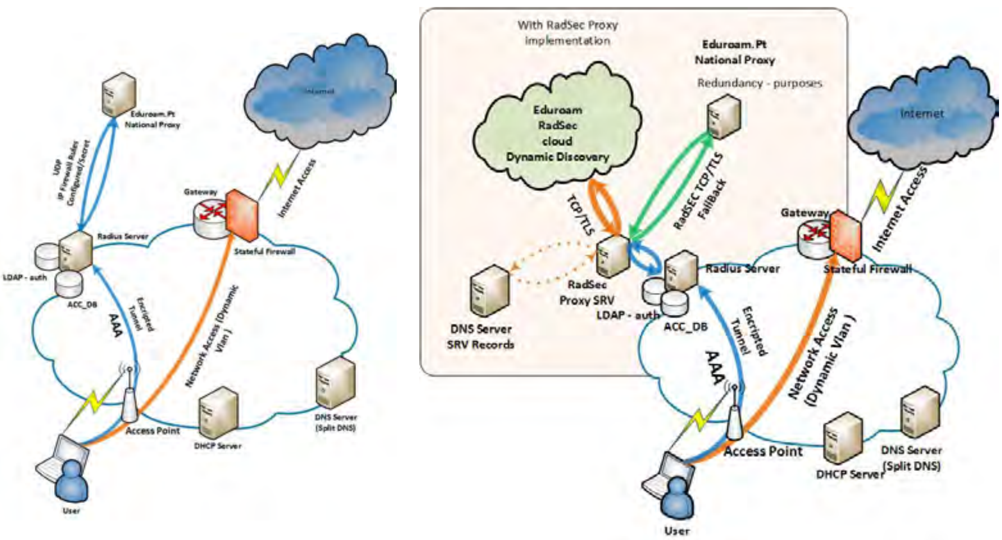

Figure 4 – RadSec Pilot – Before and After

UTAD RadSec Proxy configuration examples:

Initial Scenario

- Ubuntu 14.04.5 LTS
- Freeradius 3.0.10+git
- Firewall accept TCP port 2083

DNS SRV configuration example

zone utad.pt
IN NAPTR 100 10 "s" "x-eduroam:radius.tls" "" _radsec._tcp.utad.pt._radsec._tcp.utad.pt.
IN SRV 0 0 2083 radius.utad.pt.

/etc/radsecproxy.conf file

#External requests over TLS
ListenTLS <proxy Public IP >:2083

```
#Local requests Radius (dual stack)
ListenUDP              127.0.0.1:1830
```

```
#redirections for local Radius l
SourceUDP              127.0.0.1:33000
#redirections for outside
SourceTLS              < proxy Public IP >:33001
LoopPrevention          on

tls default {
        CACertificateFile       eduPKICAG01.crt
        CertificateFile         cert-server.pem
        CertificateKeyFile      key-server.pem
        }

#  Remove Vlan's attributes
rewrite defaultclient {
      removeAttribute    64
      removeAttribute    65
      removeAttribute    81
        }

#Clients Configurations

#Accept via outsider radsec (Dynamic Discovery)
client any {
      type tls
      host 0.0.0.0/0
      certificatenamecheck on
}

#Configuração dos servidores

#Freeradius local (auth)
server  act-local {
      host 127.0.0.1
      port 1812
      type udp
      secret XXXXXXXXX
}

#Freeradius local (accounting)
server  acc-local {
      host 127.0.0.1
      port 1813
      type udp
      secret XXXXXXX
}
```

```
#From outside to  @utad.pt  freeradius
realm utad.pt {
	server act-local
	accountingServer acc-local
}

# Server dynamic
server dynamic {
	type tls
	secret radsec
	dynamicLookupCommand /usr/share/doc/radsecproxy/examples/naptr-eduroam.sh
}

#From inside to outside dynamic RadSec redirection

realm * {
	server dynamic
}
```

File /etc/freeradius/proxy.conf

```
(…..)
#From outside for  local proxy
home_server EDUROAM_Radsec {
	type    = auth+acct
	ipaddr  = 127.0.0.1
	port    = 1830
	secret  = XXXXXXX
}

home_server_pool EDUROAM_RadSec_POOL {
	home_server = EDUROAM_Radsec
}

realm TO_EDUROAM_RadSec {
	pool = EDUROAM_RadSec_POOL
	nostrip
}
```

Debug exemple

root@radius:~# tail -f /var/log/radsecproxy.log

```
Mar 16 16:47:11 2017: createlistener: listening for udp on 127.0.0.1:1830
Mar 16 16:47:11 2017: createlistener: listening for tls on 193.136.40.148:2083
(…)
Mar 16 16:49:36 2017: connecttcphostlist: trying to open TCP connection to radius01.fccn.pt port 2083
Mar 16 16:49:36 2017: connecttcphostlist: TCP connection to radius01.fccn.pt port 2083 up
Mar 16 16:49:36 2017: verifyconfcert: certificate name check ok
Mar 16 16:49:36 2017: tlsconnect: TLS connection to dynamic_radsec.id.fccn.pt up
```

Mar 16 16:49:36 2017: Access-Accept for user teste@id.fccn.pt stationid 02-00-00-00-00-01 from dynamic_radsec.id.fccn.pt to 127.0.0.1 (127.0.0.1)
Mar 16 16:49:36 2017: replyh: passing Access-Accept to client 127.0.0.1 (127.0.0.1)

5. CONCLUSIONS AND FUTURE WORK

The pilot implementation in the involved institutions was successful regarding the objectives that where initially aimed. The pilot als implementation brought an extra level of security and redundancy to the institutions.
Accomplishing the RadSec implementation lead to the awareness that not only the technology upgrade is needed but security and manageability must thrive in the concerns of the IT staff and in the Administrations of the Institutions.
Also, DNS is a crucial component to the RadSec implementation and security concerns should be applied into the future of the pilot implementation.
The final goal of the pilot aims to create a best practice implementation ensuring that the technological knowledge can be shared with all of the institutions that want to have RadSec in eduroam.

Note: The implementation of RaSec at UTAD was founded was part of one of the objectives of the Project "SMS@UTAD - Information Security and Information Management Systems" co-financed by the European Regional Development Fund (ERDF) through COMPETE 2020 - Competitiveness and Internationalization Operational Program (POCI).

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7. AUTHORS' BIOGRAPHIES

Pedro Simões -Working in FCCN for more than 15 years, I have been connected to the eduroam project for since 2006. In these years, I have managing and maintained the Federation Level RADIUS servers and helped the Portuguese institutions on several levels, from the access points to the Radius software. I have also been involved in the different processes of the actualization and upgrade of the eduroam network to the different technologies.

António Costa - ICT specialist at (UTAD), Vila Real, Portugal, and is responsible for the coordination the areas of core infrastructure and communications, computer security areas, data center, VoIP and communications networks. He collaborates in teaching on different degrees of Computer Courses, as well as in research, extension and development projects. Holds a degree in Electrical Engineering (specialization in Electronics, Instrumentation and Computation) and a post-graduate degree in engineering area. Currently, he is in the final research stage to complete the PhD in Computer Sciences. He made several made courses or specializations which includes the Upper Course Director for Public Administration; Diploma of specialization of the Information Society for Public Administration, SIP Masterclasses and a OpenStack specialization. Further information is available at www.linkedin.com/in/ariocosta.

Fernando Reis – Has a Post-Graduation in Software Development and Interactive Systems (2010 2011) by Instituto Politécnico de Castelo Branco (ISCED 6), Engineer (5 years degree) in Information Technologies and Multimedia (1997-2002) by Instituto Politécnico de Castelo Branco (ISCED 5). From 2004 to present IT Manager at Instituto Politécnico de Castelo Branco. From September 2011 to February 2012 Invited teacher in Escola Superior de Tecnologia de Castelo Branco (School of

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Device specific credentials to protect from identity theft in Eduroam

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Keywords
Eduroam, OAuth2, SaaS, Security

1. ABSTRACT

To reduce the impact of security vulnerabilities of Eduroam the Eduroam Device Management was implemented at RWTH Aachen University. The service allows to create device specific credentials to be used as credentials when connecting to the Eduroam network. Users can create credentials, get an overview of their credentials already created and can disable network access for each device individually via a web interface. A first device manager was developed for users of RWTH Aachen, the current implementation considers the creation of device specific credentials and supporting processes for other universities within a federation.

2. Introduction

New trends like the Internet of Things, Wearables and BYOD pose new challenges to existing IT infrastructure and applications. Especially the increasing amount and heterogeneity of devices demands changes on existing IT systems. Further degrees of automation are required to successfully operate existing IT infrastructure and applications. Eduroam allows students and researchers to access the network at their home as well as remote institutions and therefore forms a basis for many of the services offered at the university.

Consequently, in the past years the number of devices accessing the internet using Eduroam increased steadily. Not only do more users access the network but also the number of devices used is inclining. The wide spread of mobile devices results in students and academic staff owning more than two devices on average, that can use Eduroam. To reduce the impact of security vulnerabilities of Eduroam discussed in (Bunsen, 2016) the creation of device based credentials for Eduroam was also implemented on the infrastructure for secure access to personalized data (Politze & Decker, 2014). Eduroam credentials can be retrieved using a man in the middle attack. The main risk of the identity theft originates from the fact that Eduroam credentials are mostly the same credentials as for other university services. For example e-mail or the campus management system, which are therefore also affected by the security issue in Eduroam. To reduce the risk of identity theft, the credentials are randomly generated per device and are not changeable by the user. Therefore it is guaranteed that they are not usable to access other university services. Even though the generation of credentials and set up of Eduroam on the device currently requires several manual steps the service endpoints to generate device based credentials have been added to the infrastructure for mobile services. This allows in a future version to automate the setup process using an app directly on the mobile phone.

3. Current State

RWTH Aachen University offers a device credentials generator for its members. A web based application that allows students and staff to create unique login names and passwords for each of their devices using only a web browser. Of course this has to be done before accessing the Eduroam network. However, there are several options to generate credentials: for example, the students can use their mobile phones internet access or can even generate their credentials at counters of the IT-ServiceDesk found in several places around the university.

The application uses the web service infrastructure described in (Politze, Schaffert, & Decker, 2016) and uses OAuth2 (Hardt, 2012) to manage which applications have an authorization to create Eduroam credentials for the user. This on the one hand allows users to gain more control over which application is accessing their data and on the other hand allows easier replacement of the components used such as user interface or backend services.

Accounts created are intended to be used only on a single device and are completely randomly generated. In the backend systems however the associated user accounts are saved. While this cannot prevent an attacker from getting the Eduroam credentials, these credentials cannot be related to any users' personal data. This does not solve the initial problem of the man in the middle attack described in (Brenza, Pawlowski, & Pöpper, 2015) but reduces the impact on other university services if credentials have been hijacked.

Furthermore, users get an overview of the credentials and devices already created and can, in case of selling or losing the device, disable Eduroam network access by removing only the device-specific credentials from their account.

One Problem that was raised during the first phase of the project was a lack of understanding of the impact of the security problem on the part of users. Another problem was that users found the user interface presented not very intuitive. These two problems compared to just entering the users' credentials when connecting to the network led to confusion and dissatisfaction for the users that already knew the previous login process. To encounter these issues, the user experience was reworked and more value is added by presenting additional usage information to the user in the current implementation of the device manager application.

4. Federated Device Management

While the first approach of the device manager was only intended for users of RWTH Aachen University, the current implementation considers offering the creation of device-specific credentials for Eduroam for other universities within a federation. This is achieved by extending the current infrastructure but also by using means that are already being used by federations such as the DFN AAI (DFN e.V., 2017). The device manager can then be offered as a software as a service to other institutions within the federation.

To comply with this requirement several extensions to the current process have to be defined which could previously be handled internally. The main issues addressed are the lifecycle of created logins and the ability for local administrators or help desks to support their users when using a federated Eduroam device management service (Grzemski & Hengstebeck, 2017).

Lifecycle management is done in three different stages: (1) when the user logs in, the identity provider presents a unique user id and a flag telling the service if the user is eligible to use Eduroam. This is usually the case for students or employees who are able to login but not for alumni who may retain their login after graduation or guests. (2) After six months without activity, the created Eudroam passwords are cleared. This is done to comply with the usual semester based organization that many academic institutions follow. (3) If more fine granular control is desired passwords have to be kept alive by the participating organization. This is performed using a white list containing all user ids that are currently eligible to access the network.

To enable local support for the users the supporting organs of the participating organization need access to some of the information logged when using Eduroam. From the experiences of the IT-ServiceDesk at RWTH Aachen University it was clear that especially the information logged during authentication of the user in the Eduroam network are crucial for support. Participating organizations therefore get access to current authorization logs of their users allowing them to trace login problems for example caused by misspelled passwords, wrong settings on the client or network abuse. This functionality is also provided as a web application.

5. Further Enhancements

In order to raise acceptance of the users to perform the additional steps to connect to Eduroam, the user experience should be as satisfying as possible. Apart from the gain in security the users should be provided additional value when using Eduroam device credentials when compared to signing in with their user credentials.

The newly created web interface, as shown in Figure 1, is supposed to be easy to use. It offers creation as well as management of existing devices and short explanations on how to set up Eduroam on the device. After login, the user is able to create new device credentials or set a new password to an existing device account with three clicks. The interface was created with mobile access in mind, such that creation of new devices is easily possible using smartphones and using mobile network.

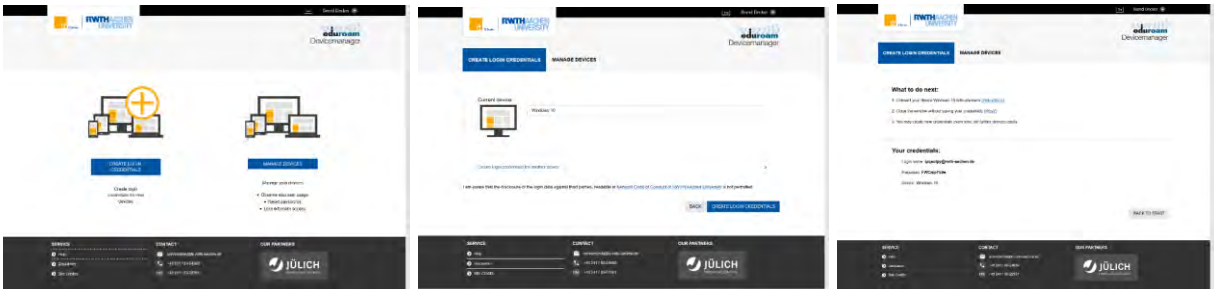

Figure 1: Three clicks to create a device-specific account

Additionally, to the reworked user interface the user is now offered to view a history of the login attempts of the device. This is similar to the information presented in support scenarios but is extended by some personal information like the approximate location during login. In contrast to the support cases, the data presented to the user is extracted from the accounting logs and is preserved for 14 days. During this time historic data can be viewed by the user. Afterwards the data is anonymized and deleted after 30 days.

The login information for each device provides additional value to the user when using the device management. Users may individually check why their device is currently not connecting to Eduroam or can check where their device has been used. In case of irregularities that would also occur when the password was hijacked, the users are able to react by resetting the compromised passwords. Figure 2 shows the data presented to the users in this step.

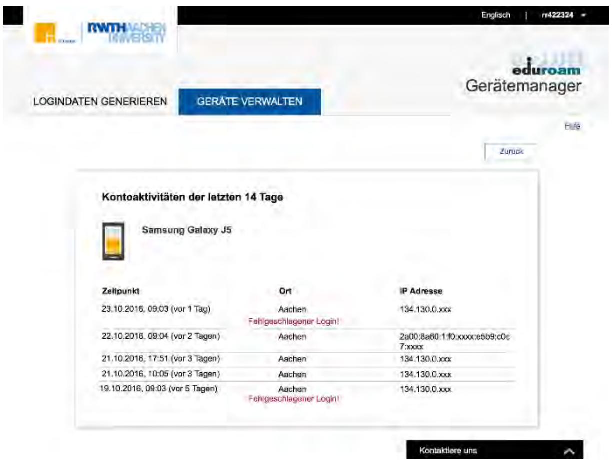

Figure 2: Overview of current devices

6. Future Work

Especially on mobile platforms a relatively slow internet connection is available using the mobile network. Using the current SOA, an Eduroam setup application would need to transfer only few kilobytes of data to create a new account. This would make it easier to connect new devices to Eduroam. Furthermore, this would also allow to automatically configure the current device. Depending on the target platform, the process of configuring the network settings on the devices is very different. Maintaining a multitude of different applications would pose an additional challenge on the overall project. Platforms for which this kind of applications are offered therefore have to be selected carefully.

Currently the Eduroam Device Manager is running at RWTH Aachen will be rolled at Jülich Super Computing Centre as a project partner. A pilot phase is used to gain more insights into running the software as a service which will then be used to further enhance the service. Afterwards the service will be made available for other cooperating institutions.

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Marius Politze, M.Sc. is research associate at the IT Center RWTH Aachen University since 2012. His research is focused on service oriented architectures supporting university processes. He received his M.Sc. cum laude in Artificial Intelligence from Maastricht University in 2012. In 2011, he finished his B.Sc. studies in Scientific Programming at FH Aachen University of Applied Sciences. From 2008 until 2011, he worked at IT Center as a software developer and later as a teacher for scripting and programming languages.

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Flooding Attacks Detection of Mobile Agents in IP Networtks

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Keywords
Mobile Agents, SYN flooding, Hellinger Distance, Chi-square, Sketch Technique, IP Networks

1. ABSTRACT

This paper deals with detection of flooding attacks which are the most common type of Denial of Service (DoS) attacks in a Mobile Agent World. We propose a new framework for the detection of flooding attacks by integrating Divergence measures over Sketch data structure. The performance of the proposed framework is investigated in terms of detection probability and false alarm ratio. We focus on tuning the parameter of Divergence Measures to optimize the performance. We conduct performance analysis over publicly available real IP traces, in Mobile Agent Network, integrated with flooding attacks. Our analysis results prove that our proposed algorithm outperforms the existing solutions.

2. INTRODUCTION

Multi-Agent Systems (MAS) are designed using independent, autonomous known as agents which can perform their tasks independently or collectively in different types of environments. The agents can be considered as processes with the ability to perform an action on the environment on behalf of user. These systems allow distribution of complex tasks amongst agents. One of the basic properties of multi-agent system is its ability of self-organization which makes it utterly desirable for autonomous and flexible system designs such as graphical applications, logistics, transportation, search engines, network management etc.
Mobile Agent Systems can be divided based into programming language by which they are developed and use: Java and non-Java based. Around 85% of Mobile Agent systems available today are built using Java, due to its inherent support to Mobile Agent programming.
Mobile Agents are becoming a focus of modern research because of their applications in distributed systems which are replacing traditional client-server architectures rapidly. However, one of the key concerns in practical implementation of Mobile Agent is the lack of protection against any threats.
The rest of this paper is organized as follows. Related work is provided in Section 3. Section 4provides the security issues that a Mobile Agent can counter while visiting another host in the network. We will discuss Sketch data structure to provide grained analysis and to derive probability distributions and will introduce different divergence measures (Hellinger Distance and Chi-square divergence) in order to compare their performance if a flooding attack happens on a Mobile Agent Network, in Section 5. Section 6 describes our proposed approach design. In Section 7, we present our experimental works and check the capability, reaction and performance of the mobile agents based on the developed design. Finally in Section 8, we present the conclusion and our future work.

3. RELATED WORK

Several researches have been proposed security solutions to detect and prevent attacks in real traffic. Most of these proposed solutions emphasize on many different detection and prevention strategies.
SYN flooding attack detection has been an interested issue for security researchers. The authors in present the effects of correlation analysis on the DDoS detection. They propose a covariance analysis method for detecting SYN flooding attacks. Existing methods for anomaly detection are based on different techniques, such as Haar-wavelet analysis,Entropy based method and Holt-Winters seasonal forecasting method. Authors compare two different algorithms (CUSUM and adaptive threshold) for the detection of SYN flooding attack. They conclude that CUSUM performs better then adaptive

threshold in terms of detection accuracy of low intensity attacks. However, both of these algorithms face problems of false alarm ratio under normal IP traffic variation.
Other work aggregates the whole traffic in one time series, and applies a change point detection algorithm to detect the instant of anomaly occurrence. The latter has a good performance in terms of spatial and temporal complexities, but presents the drawback of aggregating all traffic in one flow, where low intensity attacks cannot be detected. Furthermore, these methods use static threshold for detecting anomalies, which is not adequate with traffic variations, and may induce false alarm and miss detection. Sketch data structure uses the random aggregation for more grained analysis than aggregating the whole traffic in one time series. It has been used to summarize monitored traffic in a fixed memory, and to provide scalable input for time series analysis. Authors in propose the use of CUmulative SUM (CUSUM) over the sketch for network anomaly detection. Furthermore, they propose a new mechanism for Sketch inversion and malicious flows identification. We will exploit the Sketch data structure to derive probability distributions.
In addition, recent work experiments the histogram-based detector in order to detect the anomaly behaviors and changes in traffic distributions. They apply Kullback-Leibler divergence between the current and previous measurement distributions. Authors apply Hellinger distance (HD) on Sketch data structure, in order to detect divergence between current and previous distributions of the number of SIP INVITE request. In fact, HD must be near zero when probability distributions are similar, and it increases up to one whenever the distributions diverges (e.g. under Invite flooding attacks). In addition, they used the dynamic threshold proposed in during their experimental analysis.
From other side, several researches have been conducted over mobile Agents.
Some Articles showed what exactly it is makes Java such a powerful tool for mobile agent development, also it highlighted some shortcomings in Java language systems that have implications for the conceptual design and use of Java-based mobile agent systems.Some studies concentrate their work on the fault tolerance techniques in mobile agents, network management applications based on mobile agent technologies and how the fault tolerance techniques can improve their performance. Other articles worked on an agent-based intelligent mobile assistant for supporting users prior to and during the execution of their tasks. In addition, some works have been performed to integrate the mobile agents with the e-commerce. Some technical relevant issues are well presented. Some researches concentrated their work on security concerns (i.e masquerading, denial of service, unauthorized access and repudiation) of mobile agents and how to protect them by several techniques like for example providing logical framework designed to support large-scale heterogeneous mobile agent applications, on safe code interpretation, digital signatures, path histories, State Appraisal and Proof-Carrying Code (PCC).
Our research combines the mobile agents and the detection methods. It emphasizes on how a mobile agent can detect a flooding attacks. We develop a general framework that increases the detection accuracy and reduces the false alarm by integrating different divergence measures over Sketch technique in a Mobile Agent world.
In this paper, we will provide a brief about the security threats that a mobile agent can counter while hosting other hosts in the network in Section 4. We will discuss Sketch data structure to provide grained analysis and to derive probability distributions and will introduce different divergence measures (Hellinger Distance and Chi-square divergence) in order to compare their performance if a flooding attack happens on a Mobile Agent Network, in Section 5. Section 6 describes our proposed approach design. In Section 7, we present our experimental works and check the capability, reaction and performance of the mobile agents based on the developed design. Finally in Section 8, we present the conclusion and our future work.

4. MOBILE AGENTS SECURITY THREATS AND COUNTERMEASURES

Security is one of the key factors of MAS. In fact, a MA is one of the potential threats to computer systems and vice versa, from the host system to the MAS itself. In this part, we will talk about the main security issues related to MAS.
The security threats for MASs could be divided as follows:

- IP spoofing: consists of sending packets with a faked IP source address. The server should believe that the packets come from another host, probably a host that is allowed to establish connections with the attacked host, if the real one is not allowed
- Sniffing: it is the observation and analysis of network traffic in order to obtain relevant information (such as IP addresses and host functionalities) to perform other attacks.

- UDP flood attack: this kind of flooding attack consist on sending many UDP packets to different port of a target in random way. This target will check if there's any application on the relevant port, if not, he will be occupied to send ICMP replies and can't treat requests from legitimate clients.
- SYN flood attack: it consist on sending many TCP connection requests to a target. This latter will accept the establishment of the connection and notify the client. Except that, this one will never use them. Thereby, the server will be drown by unused connections and, eventually, will not reply to legitimate users requests.

There are many security services that can be used for securing the agents systems, for example; authentication, integrity, confidentiality and authorization.
In case of the authentication, the host needs to know the sender of the delivered agent. The agent authentication process includes verifying the entity that programmed the agent and also verifying the entity that dispatched it to the host. Basically, the agent and the host need to know with whom they are talking and dealing with, here the public-key encryption or passwords can be used,.
For integrity, checking the integrity of the agents is a technique that makes sure no one has made any changes to the agents, the agents travelling form on host to another, and communicates and exchanges their data with other hosts and other agents. In this case, we need to make sure that the agents have not been tampered with in relation to their state, code or data. Moreover, the agents could carry different types of data, for example some private data. These data should only be readable from a specific host or agents. This technique is very important to avoid an eavesdropping threat. The last service which helps to protect the agents and the hosts is authorization; the incoming agents should have a specific right to access the host information, so different agents have different authority, to protect the hosts and also to protect themselves.

5. THEORITICAL BACKGROUND

5.1. Sketch technique:

In this section, we review the K-ary Sketch data structure. Using Sketch data structure makes our framework flexible and scalable for grained analysis. No matter how many flows exist in the traffic, Sketch generates fixed-number of time series for anomaly detection. Sketch provides more grained analysis than aggregating whole traffic in one time series.
The Sketch data structure is used for dimensionality reduction. It is based on random aggregation of traffic attribute (e.g. number of packets) in different hash tables. A Sketch S is a 2D array of H × K cell (as shown in Figure 1), where K is the size of the hash table, and H is the number of mutual independent hash functions (universal hash functions). Each item is identified by a key κn and associated with a reward value vn. For each new arriving item (κn, vn), the associated value will be added to the cell S[i][j], where i is an index used to represent the hash function associated with ith hash table ($0 \le i \le d - 1$), and j is the hash value ($j = hi(\kappa n)$) of the key by the ith hash function.
Data items, whose keys are hashed to the same value, will be aggregated in the same cell in the hash table, and their values will be added up to existing counter in the hash table.
Each hash table (or each row) is used to derive probability distribution as the ratio of the counter in each cell to the sum of whole cell in the line. The derived probability distributions (we get K probability set, one per line) are used as inputs for divergence measures.

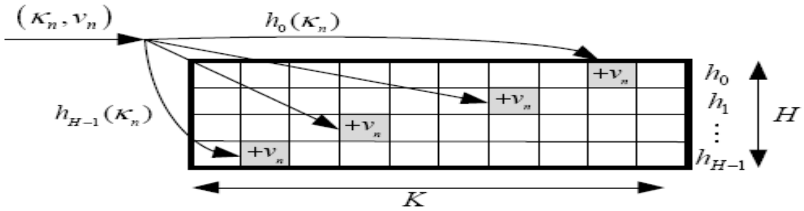

Figure 1: Sketch Data structure

5.2. Divergence Measures

These measures are used to detect the DDoS attacks based on the deviation of traffic distribution. In fact, the idea is to compare the prior distribution derived from Sketch counters in previous time slot, with the currently obtained distribution. One can use this change to detect flooding attack, because the counter of one cell will increase significantly with the number of sent requests, and the probability distribution deviates at the start and stop instants of the flooding attack.

5.2.1 Hellinger Distance (HD):

Hellinger Distance (HD) is used to measure the divergence between two sets of probability values. For two discrete probability distributions P = (P0, P1….,Pk−1) and Q = (Q0, Q1,…,Qk−1), with Pi ≥ 0, Qi ≥ 0 and

$$\sum_{i=0}^{k-1} pi = \sum_{i=0}^{k-1} qi = 1$$

The HD between current distribution P and prior distribution Q is defined as:

$$H\,D\,(P,Q) = \frac{1}{2}\sum_{1=0}^{k-1}(\sqrt{pi} - \sqrt{qi})^2 \quad (1)$$

Where HD satisfies the inequality 0 ≤ HD (P, Q) ≤ 1, and HD (P, Q) = 0 if P = Q. HD is a symmetric distance (e.g. HD (P, Q) = HD (Q, P)), and induces two spikes, one at the beginning of change, and the second at the end of the change.

5.2.2 - Chi-square divergence:

x2 divergence is used to measure distance between two discrete probability distributions (P and Q). For 2 probability sets P = (p1, p2, p3. . . pn) and Q = (q1, q2, q3. . . qn), with Pi ≥ 0, Qi ≥ 0 & $\sum_{i=0}^{k-1} pi = \sum_{i=0}^{k-1} qi = 1$

The Pearson x2 divergence between P and Q is given by:

$$x^2\,(P||Q) = \sum_{i=1}^{n} \frac{(Pi-Qi)^2}{Qi} \quad (2)$$

Where Q is the estimated probability distribution and P is the measured probability distribution, and x2 (P||Q) is the distance between distributions P and Q.

For hypothesis testing, such as H0 (normal traffic hypothesis) and H1 (traffic with anomalies), x2 values can run from zero into infinity. x2 will be zero if P and Q are identical (Pi = Qi) under hypothesis H0, and x2 increases as the distributions become dissimilar, and eventually so high (infinity) when the two distributions are independent (P ≠ Q)under hypothesis H1. It is important to note that x2 divergence is nonnegative and the division 0/0 is treated as 0, and the division by zero is replaced by a very small value ε .

The x2 divergence between 2 probability distributions P and Q must be near zero under normal traffic, with a large deviation (one spike) when distributions change occurs. x2 is asymmetric (x2 (P||Q) ≠ x2 (Q||P)), and its symmetric version raises two spikes. One spike at the beginning and the second at the end of the attack.

$$x^2\,(P||Q) + x^2\,(Q||P) = \sum_{i=1}^{n} \frac{(Pi-Qi)^2 + (Pi+Qi)}{Pi * Qi} \quad (3)$$

We intend to use Pearson chi-square divergence (asymmetric) to detect anomaly through the detection of deviations from normal traffic profile, and we will modify the input time series to constrain x2 to raise alarms (spikes) for the whole duration of attack. In [30], authors prove that x2 divergence behaves better than all classical divergences (Hellinger distance, Kullback-Leibler, Likelihood, etc

6. PROPOSED APPROACH

The proposed approach for anomaly detection in Mobile Agent networks is based on Sketch and divergence measures (Hellinger Distance and Chi-square)

The detection system records the number of monitored point (e.g. #packets, #SYN, #flows, etc.) in the Sketch for each discrete time interval T. Random aggregation of traffic flows in Sketch is the first step of our processing, followed by time series forecasting with divergence measures (Figure. 2).

Figure 2 : Architecture of the proposed approach for network anomaly detection.

During each interval, the destination IP address (DIP), for each packet containing a SYN segment, is hashed by H hash functions. The resulted hash value by the ith function (j = hi(DIP)) is used as index of the associated counter Si,j with DIP. Each arriving SYN segment increments the associated counter.

Our analysis will be focused on TCP SYN flooding by counting the number of SYN.

At the end of each epoch T, we derive probability distributions from Sketch. First, we get the sum of the counter in each line, and the probability pi,j in each cell is calculated as the ratio of each counter to the total number of SYN:

$$Pi,j = Si,j.Counter \sum_{j=0}^{k-1} Si,j.Counter \quad (4)$$

Each cell Si,j becomes a data structure, that contains: current counter, current and previous probabilities. Therefore, each line (or hash table) provides two probability distributions: the first one is from previous interval and used as reference distribution Qi. The second one is from current interval Pi, and used to measure the divergence from the reference distribution, in order to detect anomalies. Divergence measures between the current (Pi) and reference probability (Qi) distributions is calculated for each line in the Sketch, at the end of each time interval (i.e. at n.T).

During malicious activities, the divergence measure D(Pi||Qi) produces spikes, and when more than L (L < H) divergences resulted from different hash tables exceed a dynamic threshold, an alarm is raised.

To detect deviations in the time series resulted from divergence measures, we derive a subsequent time series containing the values of D(Pi||Qi) without spikes. In this last time series (without large values), we define a dynamic bound of μi+ασi. Significant deviations are larger than the dynamic bound:

$$D\,(Pi\|Qi) > \mu i + \alpha \sigma i \quad (5)$$

Where D(Pi||Qi) is the divergence measure in the time interval n.T for the ith line in the Sketch, and μi & σi are the mean and the standard deviation respectively of smoothed time series that doesn't contain spikes (D^(Pi||Qi)). μi and σi are updated dynamically using the Exponentially Weighted Moving Average (EWMA):

$$\mu i = \beta\mu(i-1) + (1-\beta)\, D^{\wedge}(Pi||Qi) \ (6)$$
$$\sigma i^2 = \beta\sigma(i-1)^2 + (1\text{-}\beta)(D^{\wedge}(Pi||Qi) - \mu i)^2 \quad (7)$$

The threshold is updated dynamically with the value of μi and σi as shown in above equations. α is a parameter used for calibrating the sensitivity of the detection algorithm to variations. It is also used to reduce the false alarm rate. Under normal traffic, divergence D (Pi||Qi) falls inside the bound of μi + 2σi. When D (Pi||Qi) exceeds the dynamically updated threshold over L lines, an alarm is triggered.

7. EXPERIMENTAL WORKS

In this section, we present the performance analysis results for integrating divergence measures over Sketch, for detecting SYN flooding attacks in a mobile agent network. As we want to compare 2 divergence measures (HD & x2) over Sketch for the detection of flooding attacks, we will implement a mobile agent network.
For the sake of simplicity, we focus our analysis on the detection of TCP SYN flooding attacks, as it is the widely used attack for DDoS in these days.

7.1. DATASET

The following techniques and tools are used: Two workstations with 8 GB and 768 MB of RAM respectively, which run Windows Server 2003 and a number of Mobile Agents are used.
We have considered the above describe mobile agents will have to execute the similar path. To measure the capability of the proposal towards eavesdropping threat, a test environment is set up using the above mentioned computers as shown in Figure 3. Computer A is considered to act as trusted server (TS) and computer B runs many host nodes simulated through various port numbers as well as the home node in a virtualized mode. Ethereal will be running regularly over computer A. its job is to collect packets in the mobile agent network and store them for a period of 4h00 from 18/02/2017 07h30 to 11h30. These traces are used to test the efficiency of divergence measures. IP addresses in the traces are scrambled by a modified version of tcpdriv tool, but correlation between addresses are conserved. We analyze these 8h30 traces using Sketch data structure, with a key of the Sketch (κn = DIP), and a reward vn = 1 for SYN request only, and vn = 0 otherwise. We set the Sketch width K to 1024, and the number of hash H to 5.

Figure 3: Experimental Lab

Afterward, we inject 12 real distributed SYN flooding attacks with different intensity inside this trace. These attacks are inserted each 30 minutes (on instants t=30, 61, 90, 127,157,187, etc.) and span for 10 minutes. These different intensity attacks are shown in Figure 4. The first attack begins with a value of 900 SYN/min and decreases until 280 SYN/min.

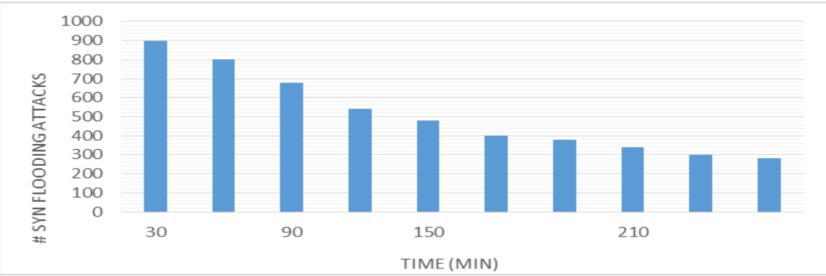

Figure 4 : SYN flooding Attacks

Figure 5 & Figure 6 show the variation of total number of mobile agents' packets before and after the injection of SYN flooding attacks. By comparing these variations, we might not notice the differences between both figures without deep inspection. Inserted attacks don't induce heavy deviations in the time series of the total number of SYN requests. This can be explained by the fact that the intensity of SYN flooding attacks is not large compared to the intensity of the total number of SYN segments. In such cases, the detection of attacks is very challenging, because no heavy changes in the time series describing the variations of the total number of SYN, and the intensity of the SYN flooding attacks is buried by the large number of SYN (as shown in Fig. 4) before attacks injection.

7.2. EVALUATION STRATEGY

In this section, we present the evaluation results of the application of these divergence measures on the mobile agent IP traces.

First, we begin our analysis by applying HD & x2 divergence over the traces (before attacks injection). We set the dynamic threshold as given in Eq. 5. We will begin our analysis by applying the HD and Chi-Square over the mobile agent IP traces (before injection SYN flooding attacks). Figure 7 & Figure 8 show the variation of these 2 divergence algorithms as well as the dynamic threshold (dashed line) before the injection of attacks. When the value of divergence measures is larger than threshold in at least 3 hash tables in the Sketch, an alarm is triggered. We see that both algorithms were able to detect anomalies at different time (t=90, 127,157,180 etc.). These anomalies are temporary and they don't persist more than many minutes. However, there are more anomalies that can be detected by using the source IP address as the key of the Sketch, but we will restrict our analysis to SYN flooding attacks. In fact, after the manual verification of traces, we found that HD triggers 4 false alarms, and the x2 divergence achieves very high detection accuracy with 1 false alarm.

Indeed, we continue our analysis by applying the HD and Chi-Square over the mobile agent IP traces (after injection SYN flooding attacks). We noticed that in case of Hellinger Distance using a dynamic threshold, we obtain 4 false alarms with a detection of 100% (Figure 9). However, in the case of Chi-Square, we did not obtain any false alarm (Figure 10). We found through our conducted experiments that Chi-square divergence performs better than HD in terms of reducing false alarm, with less effort for tuning the dynamic threshold. The intensity of raised spikes in Chi-square increases with the intensity of attacks and dynamic threshold becomes useless.

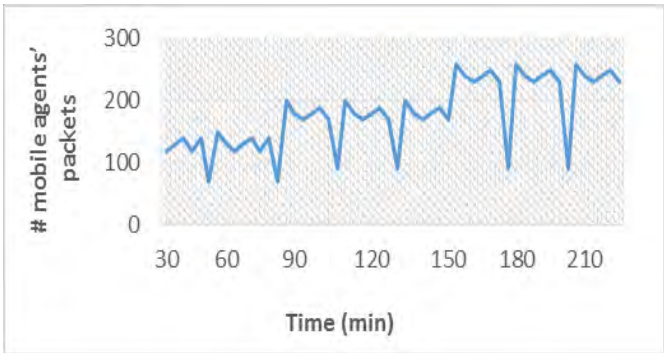

Figure 5 : Total number of mobile agents' packets

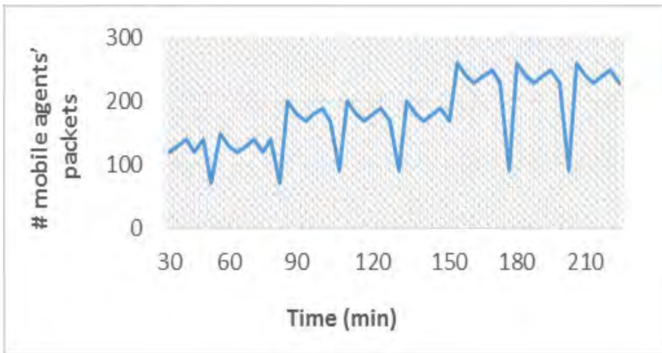

Figure 6 : Total number of mobile agents' packets after SYN flooding attacks injection

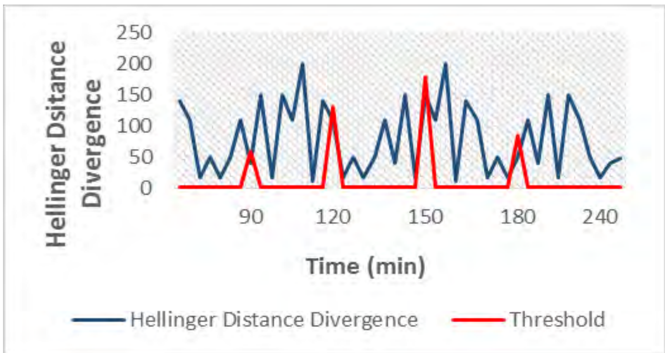

Figure 7 : Hellinger Distance before attacks

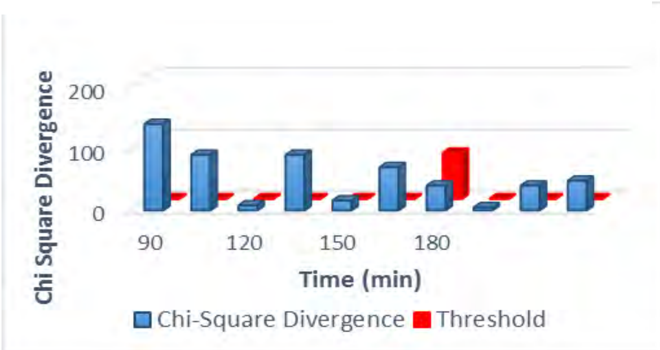

Figure 8 : Chi-square before attacks

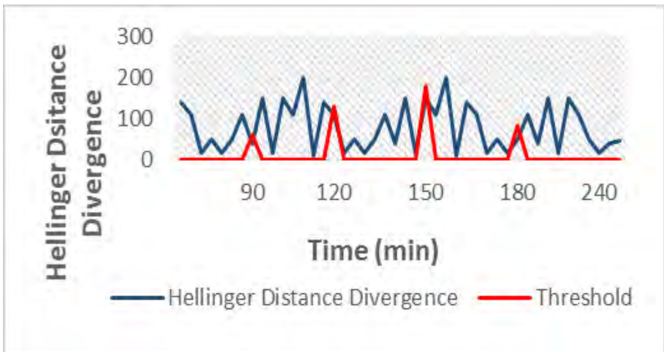

Figure 9 : Hellinger Distance after attacks

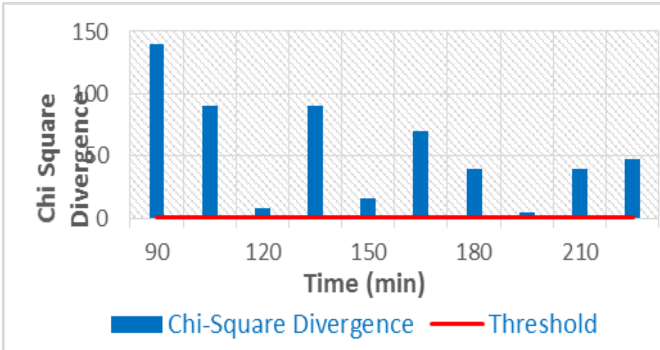

Figure 10 : Chi-square after attacks

8. CONCLUSIONS

In this paper, we analyzed the accuracy of 2 divergence measures (HD & Chi-square divergence) over Sketch data structure for network anomaly detection. We compared their performances in terms of true positive and false alarm ratio, over real mobile agents IP traces with injected real distributed SYN flooding attacks at known instants.

Afterward, we used dynamic threshold for achieving the best tradeoff between false alarm and true detection.

We found that HD performs a good detection, but with higher false alarm ratio than Chi-square divergence. We can conclude that Chi-square conducts better detection than HD for mobile agents' network. Furthermore, the intensity of triggered spikes by Chi-square divergence increases significantly with the intensity of attacks. It is important to note that these divergence measures with Sketch are computationally efficient for handling traffic on mobile agents' traffic.

In our future work, we will introduce another divergence measure which is Power Divergence in order to compare its performance on the detection of flooding attacks over mobile agents with Chi-square and Hellinger Distance. In addition, we will focus on providing additional information to pinpoint malicious flows, in order to trigger automatic reaction against ongoing attacks. We also intend to provide a method for reducing the amount of monitoring data on mobile agents networks, and to analyze the impact of sampling on the precision of this divergence measure.

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Research Data Infrastructures – A Perspective for the State of North Rhine-Westphalia in Germany

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Research Data Management, Cooperative Storage Infrastructures, Storage of Research Data

1. ABSTRACT

With the digital transformation progressing fast, scientific research is massively affected by the ever-increasing amount of digitally generated research data. New ways have to be established to properly manage this digital research data to ensure that the standards of good scientific practice, first of all the reproducibility of scientific results, can be fulfilled. Sustainable management of digital research data requires standards for metadata annotation and a future-proof infrastructure for handling and storing these data. In this paper, we describe the current state of affairs in Germany with respect to research data management (RDM) and the establishment of a national research data infrastructure. The special focus is on the currently ongoing activities in the state of North Rhine-Westphalia to start implementing research data infrastructures for universities through several cooperative multi-university projects, tailored to the specific needs and approaches of the participating universities.

2. RESEARCH DATA MANAGEMENT IN GERMANY

During the last decades, an enormous quantitative and qualitative growth of research data, i.e. data used or generated during a research project, can be observed. Depending on the respective scientific discipline, research data exist in many formats including numerical data, text, transcripts, images, video, audio recordings, etc.

The relevance for research data itself has drastically increased, as technology is making it feasible to ensure reliable verification of results and permits new and innovative research built upon existing information. Research data has shifted from being considered a residue of the scientific process, to an important resource for future research.

Worldwide, several research funding institutions as well as various publishers are more and more requiring good data management practices from scientists, such as the use of data management plans or the publication of research data associated to classical paper publications. On a national level, several countries have built technical infrastructures for the handling of research data.

In Germany, the importance that has been given to the topic of RDM is reflected and has been promoted by several organisations and institutions, such as the German Research Foundation[1] (DFG, 2013), the German Rectors' Conference[2] (HRK, 2015), the Alliance of Science Organisations in Ger-

[1] The German Research Foundation (DFG) is the largest independent research funding organisation in Germany, see also www.dfg.de/en/ (retrieved March 3, 2017).
[2] The German Rectors' Conference (HRK) is the voluntary association of public and government-recognised universities and other higher education institutions in Germany, having currently 268 member institutions in which around 94 per cent of all students in Germany are enrolled, see also https://www.hrk.de/home/ (retrieved March 3, 2017).

many[3] (Alliance of German Science Organisations, 2010) and the Council for Scientific Information Infrastructures[4] (RfII, 2016) among others. These statements come along with similar international activities, just to mention the vision of the European Commission where "a scientific e-infrastructure that supports seamless access, use, re-use and trust of data" (European Union 2010, p. 4) is described.

Besides this, the Council for Scientific Information Infrastructures has stated the need for national coordinated activities, and described a National Infrastructure for Research Data (known under the German acronym NFDI) which is expected to be built within the next 15 years. The NFDI on the one hand is regarded as a net of data centers with discipline-specific focus, which will offer solutions for RDM. On the other hand, the NFDI will have to focus on the needs for standardization and basic general services, addressing the explicit wish of the Council to facilitate crossing disciplinary borders and therefore allowing universities or groups of universities to play an important role providing basic data services for researchers and therefore being part of the NFDI (RfII 2016, p. 38).

As a consequence, universities have to face the challenge to build and develop (infra-)structures for a professional research data management (RDM) to support their researchers, such as technical (storage) infrastructures, training and support, research data policies, etc.

Being a collective task, cooperation between universities and research institutions seems to be the best road to go.

3. ACTIVITIES IN GERMAN FEDERAL STATES

Due to its federal organisation, several coordinated activities at German federal state level can be observed.

In Baden-Wuerttemberg, the Ministry of Science, Research and Arts (MWK) identified several fields of action in the context of digitalization of science, such as licensing of electronic information, digitalization, open access, research data management and virtual research environments. Within each of these topics, several projects have been funded. In the context of RDM, a starting project called bwFDM-Communities was funded during 2014 and 2015 and had the aim to contact researchers among all universities within Baden-Wuerttemberg as to understand the needs for research data management infrastructure. During the project, 627 interviews were carried out. In total, 779 persons were asked about their usage of data within their research activities, as to understand the needs of infrastructure. Description of methodology and the results can be found within a final report (Tristram 2015, German only), and the huge amount of resulting data is properly visualized on the web[5]. The outcome of the project spawned a wave of funding, where the ministry awarded grants with a total amount of 3 million Euros for 7 projects that are being carried out by different universities across Baden Wuerttemberg. The projects address different needs in the research data management cycle, first results are expected this year, and will be available for all universities within the state of Baden Wuerttemberg.

In Hessia, the universities and the state have settled a target and performance agreement for the future of scientific infrastructure of the universities within the state for the years 2016-2020. For research data management, the goal is to develop a joint RDM-infrastructure that can be used by the

[3] The Alliance of Science Organisations in Germany (Allianz der Wissenschaftsorganisationen) is a union of the most important German research organisations. It issues statements relating to research policy and funding and the structural development of the German research system. See also https://www.leopoldina.org/en/about-us/cooperations/alliance-of-science-organisations/ (retrieved March 3, 2017).

[4] The Council for Scientific Information Infrastructures (RfII) was initiated by the Joint Science Conference of the Federal States (GWK) and the Federal Government of Germany for a service period of four years in 2014. The 24 members represent a broad spectrum of scientific disciplines and institutions. The Council´s scope of work is the strategic development of a contemporary and sustainable infrastructure for access to scientific Information. See also http://www.rfii.de/en/ (retrieved March 3, 2017)

[5] See http://bwfdm.scc.kit.edu/101.php. (retrieved March 17, 2017).

universities within the state. The project is funded with a total of 3.2 million Euro and will be evaluated at the end of the third year by the German Research Foundation (DFG). For the enforcement of the project and to ensure communication, part of the funds have been distributed for staff being responsible for RDM at each of the five universities within the state of Hessia.

In the state of North Rhine-Westphalia (NRW), the Digitale Hochschule (DH-NRW) is a cooperation structure of the 40 public universities and the Ministry of Innovation, Science and Research (MIWF) of NRW to address the challenges of digitalization and to foster cooperation in information management at the universities within the state. It aims to develop strategies in the field of research, teaching, education and infrastructure such as to initiate projects and cooperation across universities.

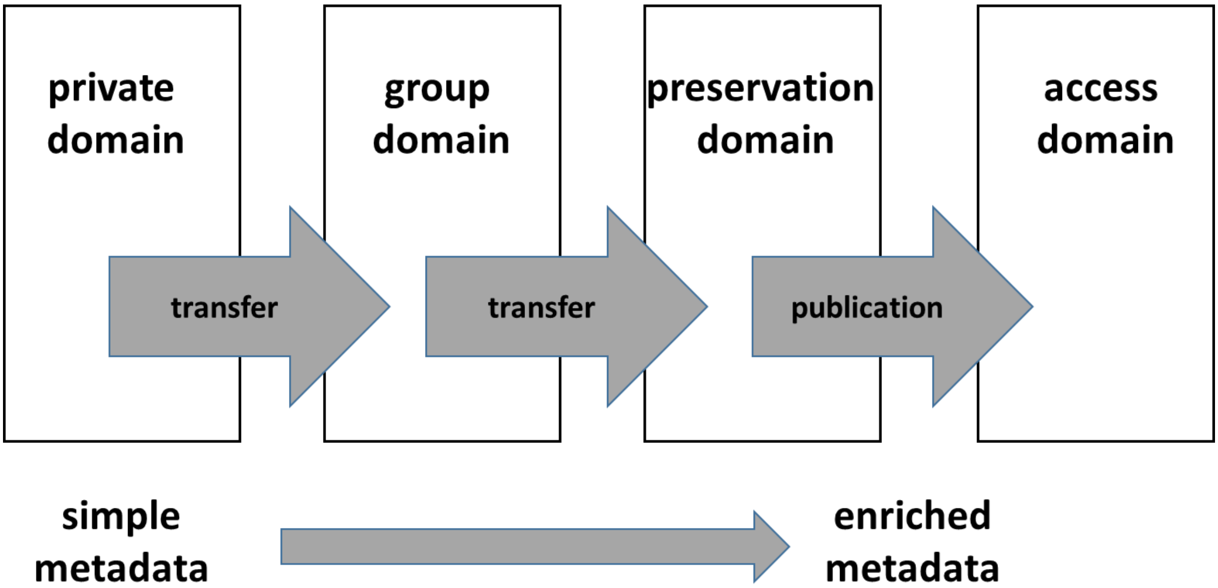
Concerning RDM, on a call of the DH-NRW (formerly DV-ISA), a working group was formed in 2015, composed of representatives of libraries, IT-centers and researchers from 9 universities within the state with the aim to chart the activities regarding RDM found within all universities in NRW. Similar to known national and international survey results to RDM (part of the activities has been reported in (Thoring, 2016)), the biggest need for services for RDM can be found in the fields of information and technical infrastructure (DV-ISA, 2016). After the status quo analysis, in spring 2016 a follow-up expert group composed of 6 representatives of libraries, IT-centers and researchers from universities in NRW was nominated within DH-NRW. The aim for this group was to work out a proposal for sustainable RDM-services for universities in NRW, to ensure cooperation and coordination within the universities and to establish solutions to RDM, which can be incorporated into a developing national strategy. The so-far focus of the working group was on communication and information for ensuring the possibility of cooperative approaches within universities. Some of the results are the monthly exchange format "Jour Fixe RDM" (regularly visited by 20-30 different participants from the universities of NRW, coming from libraries, IT-centers and research support departments) and general information material as a set of slides for individual re-use[6]. Having started the discussion about RDM with different stakeholders, the dialogue and coordination of a planned NRW-wide storage-infrastructure for research data was initialized.

4. APPROACHES FOR STORAGE INFRASTRUCTURE IN THE STATE OF NORTH RHINE-WESTPHALIA

A widely-used model from a technical point of view for describing the management of data during the research process is the curation domain model (CDM; see Forschungsdaten.org, 2015; derived from Teloar, A. Groenewegen, D., Harboe-Ree, C., 2007). It describes 4 domains: The *private domain* describes the handling of data by a single researcher or a small team of researchers. On most large projects data is handled by bigger groups of researchers, a lot of times crossing institutional and disciplinary borders, this is designated as the *group domain*. The handling of data in a group domain requires explicit metadata to be understood not only by an individual researcher (as in the private domain). At some point within the research process, the data is to be archived. This is part of the principles of good scientific practice, to preserve research results, especially when publications have been derived from them. In this case, called the *preservation domain,* the data must be provided with more metadata, which can be descriptive but also technical, if for example the data is not publicly available, so it has to cover rights management, and also it has to be ensured that the data is persistently referenced, with a PID-Service (i.e. Handle, DOI, URN, etc.). The last described *accessibility domain* addresses the case, when research data is made publicly available, for example through a repository or a publisher.

The four domains in the curation domain model also give a clue that the physical systems used for generating, analyzing and storing research data will differ between these domains. While researcher will often use their personal computers and laptops (often with external USB disks, as (Thoring, 2016) shows) in the private domain, collaborative platforms (like sync & share cloud services, shared network drives or Sharepoint) might be used in the group domain. The preservation domain is often realized through a repository usually operated by university information or library services. The access domain will often also build on repository systems, but also community or project specific web based solutions can be found.

[6] https://doi.org/10.5281/zenodo.165126 (retrieved March 17, 2017).



The big issue here of course is the sustainability and long-term operation of these various systems to ensure access to research data for verification and reuse.

To create a sustainable infrastructure for research data management, especially for storage and long term availability of data, the board of IT directors of the universities in North Rhine-Westphalia (ARNW) in conjunction with DH-NRW has discussed possible solutions in a September 2016 workshop.

Out of the discussion of different user needs and requirements created through pre-established IT-environments at various participating universities, this workshop resulted in the formation of three multi-university consortia setting out to create joined grant proposals for solutions that address their shared research data management infrastructure needs.

5. THREE APPROACHES, ONE FOCUS

The common aim of all three consortia is the creation of sustainable infrastructure to support all or parts of the domains in the CDM. The individual approaches differ widely:

1. One consortium focusses mainly on a common storage systems solution with sub-systems established at multiple data center locations of the participating universities, but providing a unified common name space for data access, thus facilitating cross university research collaborations. At each participating university, a 2-tiered configuration is planned, addressing the group and preservation domain. Besides technical cooperation, the joint project will foster the creation of expertise in running such complex systems in a way to fit and benefit the specific demands on RDM processes within different user communities. An open standards interoperability strategy for later expansion with potentially different vendor storage products is planned.
2. A second consortium of universities focusses on the tamper- and audit-proof archival of research data. For data security and efficient re-use of these data, distribution of multiple data copies to the decentralized storage systems located at the data centers of the three participating universities is a key concern. Coordinated data life cycle management of these data instances (like implementation of retention and deletion periods for all data copies) and unified data access control (with identical rule sets for all data copies) are essential parts of this project.
3. In a third project, the creation of a cooperatively operated sustainable storage and service infrastructure for all stages of the data curation domain model, i.e. for creation, analysis, collaborative exchange, storage, archival and accessibility is planned. This project will be exclusively based on open source freeware software solutions: Ceph as a future-proof Software Defined Storage solution and OpenStack as an on-premise cloud platform for the flexi-

ble, resource efficient provision of virtual system resources for research groups along the stages of the data curation continuum from scientific computation and analysis down to the hosting of web based community focused accessibility for research data.

With the later project being coordinated by one of the authors, this will be the focused in more detail in the next section with an exposition on the design motivations for this innovative hardware-only approach to a research data infrastructure.

All three projects are meant to be incorporated into the established cross-university cooperative IT solutions landscape in NRW and align with other projects focused on different curation aspects of digital research data:

1. Long term archiving and backup of data, mainly in tape archives: a consortium of 13 universities in NRW are joined in a common project for the IBM Tivoli Storage Manager software product for the management of tape archive systems. This is seen as common basis for long term archiving for all above the research data infrastructure projects.
2. Offering for a common repository service: the university library service center (hbz) of NRW is pursuing a project to create a SaaS offering for a research data repository utilizing the Rosetta software product by ExLibris.
3. Research data services orchestrating the interconnection of data management utilities along the stages of the curation domain model: based on the well-established NRW-wide university operated cloud storage sync & share platform sciebo (Vogl, 2016), which is already supporting some 800 research project groups as a collaboration and storage resource, a set of research data services is planned to support the process of enriching the meta data and creation of submission and archival information packages (according to the OAIS model).

6. A SUSTAINABLE OPEN SOURCE FREEWARE APPROACH TO A RESEARCH DATA INFRASTRUCTURE FOR MULTIPLE UNIVERSITIES

The ongoing digital transformation has led to an exponential increase in digital data – and this is more than just a lip service to the currently unavoidable digitalization buzzword battle. It is e.g. very manifest at University of Münster and can be visualized with the development of storage capacity provisioned by the IT center and the backup data volume consumed in the central backup system. From 2010 onward, the disk capacity of storage systems has surpassed the backup data volume – the growth of data has led to a situation, where tape backup/restore and archival are no longer practicable – data has to remain available online and users rely on the data integrity features of the online storage systems to ensure the safe preservation of their data. Besides an ever-growing demand for user accessible highly performing online storage systems (tier 1 storage), a clear trend also leads to background storage systems, which are (at least currently) disk based but not so much performance oriented and not directly user accessible - they serve as online data pools for backup and archive systems (tier 2 storage), since tape archives are not suitable to provide the required restore times for large backup data sets. With disk capacities still growing (faster than tape) and a shift to affordable high volume nonvolatile solid state storage imminent, tape storage seems to be headed for a rather small niche of applications where offline media are of special importance, if not becoming completely obsolete. Still, tape used to be the medium that was accredited with very long term stability (30 years estimated archive life e.g. for IBM 3592 tape cartridges).

The preservation and accessibility of digital data for long periods of time has thus to be well considered for an all online storage future: 10 years at the minimum, this being the usual data retention requirement imposed by funding agencies, but for particularly valuable research data, unlimited preservation as part of the human heritage is called for. In such a context, a static offline media approach is doomed to fail, due to unavoidable media obsolescence. For online storage systems with a typical life cycle of 5-7 years, a passive approach to data preservation is out of the question, anyways.

The only way to deal with this, is constant migration of data to fight media and hardware obsolescence and silent bit flip data corruption. Sustainable storage systems thus must have instruments for data migration build in. Experience has shown how painful, and not unlikely even lossy, the migration from one file system based storage system to the next generation can be.

Object storage systems with standardized metadata hold the promise of a smooth migration process, especially when new storage nodes can be added to such a storage cluster on demand during operation, and obsolete hardware can be vacated by targeted data migration and then be taken offline. Data redundancy in the storage layer safeguards data loss due to media failure or corruption, and data replication between data center sites secures against catastrophic events.

A further possible step for obsolescence prevention is the reliance on open source software defined storage solutions, which eliminate the risk of end of life products – an active developer community takes care of the code-stewardship and in the worst case, skilled staff at universities can provide basic support to keep the system operational, even when fixes in the source code are necessary.

To create an infrastructure not only for research data storage, but also one that supports the research processes in data generation, analysis, and accessibility, a common approach is to provide an on-premise cloud environment for self-provisioned, scalable science & engineering resources through virtualized systems.

This can also be an infrastructure or platform as a service (IaaS, PaaS) for joint cloud-like collaborative solutions - such as sciebo, for instance.

For software defined storage, Ceph (Weil, 2006) currently is the top ranking open source freeware solution that holds the promise to deliver on all the above stated objectives for sustainable research data storage. With respect to cloud stacks, OpenStack (OpenStack, 2017) has established itself as the main open source product in the last few years.

These two products thus have been selected as the software part for this project – with confidence among the consortium partners that an open source freeware approach is the right way to go. It is further planned to leverage synergies, minimize operational cost and establish self-supported maintenance structures with minimum reliance on commercial support by pooling the skill and experience of the storage systems and virtualization specialists from the IT centers of the consortium universities for mutual assistance and stand in, for joint work like release testing and rollout concept, as well as coordination of overlapping administration tasks such as cross site data replication planning. This of course will be a virtual structure with a focus on periodical meetings for exchange and planning, jointly organized trainings and online collaboration resources for coordination of administrative activities. But some 20 years of experience with cooperation in the context of the IBM TSM backup and archive software has shown, that such cooperation is possible, effective and sustainable. So, there is reason to expect that it will be possible to bring this kind of multi-university IT operations cooperation to an even higher level in the context of open source software, where the field of activities for the IT specialists is much wider, beyond administration of a commercially supported proprietary product.

Open source freeware has grown in importance over the last 25 years – symbolized by the now tantamount presence of Linux in server computing not only in the academic and research domains. Similar developments are imminent in other fields of IT infrastructure – most of all software defined storage solutions and cloud stacks – and a major change of paradigm seems to be currently taking place there. The open source software packages that are part of the current planning may change in popularity in the next 15 years, but basic concepts of software defined infrastructures, open source and freeware, and cooperatively provided on premise IT services for higher education and research are to stay.

7. DISCUSSION

With good reason, the RfII recommendations for research data management in Germany have been subtitled “Performance through Diversity”. NRW as Germany’s largest state with some 40 universities, 14 of these research universities, offers a whole lot of diversity, even in the approaches and strategies towards sustainable research data management. The three approaches towards research data infrastructure described above will create offers that support both the phase of the acquisition and processing of data in the course of scientific work as well as the long-term archiving considerably better and more comprehensively than is currently possible. They aim at supporting consistent and reliable data storage in all domains of the research process. All three projects thus provide a discipline-agnostic storage infrastructure that offers the capacity and performance to cope with the research data management requirements of the respective universities, with the additional benefit of multi-location replicated storage for protection of sensitive data and data lifecycle support.

The timeline for the establishment of the national research data infrastructure (NFDI) laid out in the RfII recommendations is a realistic 15 years. With the life cycle of IT system platforms being in the 5-7-year timeframe, these three approaches will long have given way to follow ups by then. It is an iterative approach, and as it is common with research (and IT) projects, objectives and concepts have to be progressively adjusted to the ongoing developments. The projects described here will provide urgently required infrastructures for research now – tailored to the needs of the research groups within the universities in the respective consortia – and will help foster even deeper cooperation between universities in jointly operating IT services. Thus they will provide a valuable and lasting contribution to the long-term aim of a national research data infrastructure.

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The National Repository of Theses: A Short Polish Case Study

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1. ABSTRACT

The aim this study is to outline the main assumptions and challenges that occurred while introducing the national repository of theses in Poland. More specifically, we discuss the legal basis and other conditions of the repository, its architecture, implemented business processes, and some the most interesting technical details and performance statistics. Particularly, we show that a simple datastore based only on a filesystem could be more efficient and cheaper than a NoSQL database, which is quite fashionable nowadays. Presented comments and remarks regarding development and deployment of the information system and selected statistics of the working software may help other parties to improve their repositories or take a decision regarding new solutions.

2. INTRODUCTION

In recent years, many universities and research units decided to preserve the works of their students and researchers in an electronic form. To properly manage data, it requires a dedicated storage with appropriate software. In the literature, such information system is usually named as a repository of Electronic Theses and Dissertations (ETD), which may be considered as the particular case of an Institutional Repository (IR). The difference between them is that the IR covers all possible documents of an institution; whereas, the ETD repository includes only theses and dissertations of students or researchers. We have to note that there are also other types of repositories like disciplinary, aggregation, governmental repositories, etc., but in numbers, most of them are institutional (Yiotis, 2008).

The main purpose of introducing ETDs is to publish students' works (Yiotis, 2008), so they can become easy available for a wider audience. In addition, they may be retained cheaper and longer than in a printed form. We have to be aware that investments in EDTs do not produce any direct revenues but increase access to students' works and allow their wider dissemination (Galea, 2014). An embarrassing problem appearing in universities is plagiarism (Kravjar & Dušková, 2013). The ETDs may be conveniently integrated with anti-plagiarism programs to locate such practices. Nevertheless, this issue is outside the scope of this study.

The works may be openly available on the Internet or only within a local institutional network. There is no clear evidence that worldwide published works have a bigger impact that the others because there is no relationship between their downloads and citations. However, one may observe a local influence, because a thesis becomes discussed again in a local academic environment (Bennett & Flanagan, 2016). Some advocate that an internet repository is not synonymous to open access and the authors should have opportunity to take decision about openness their work (Schöpfel & Prost, 2013). Since some researchers prefer to publish subsequent publications based on their thesis, there are some concerns whether the works openly stored in an ETD are welcome for future publication in journals or university periodicals. The detailed research has shown that most redactors would likely consider such works for publication or with some preliminary check (Ramirez, Dalton, McMillan, Read, & Seamans, 2013).

Many institutions developed their own unique software to manage electronic theses and dissertations but the most worth noting are open source solutions, which are deployed in several places. For example, about half institutional repositories over the world use DSpace[1] (developed at the University of Southampton) or ePrint[2] (developed at the Massachusetts Institute of Technology) platforms (Ramirez, Dalton, McMillan, Read, & Seamans, 2013). Other important repository platforms are as follows: Virginia Tech University's ETDdb[3], Greenstone[4], Digital Commons[5], OPUS[6], dLibra[7], etc. (Galea, 2014; Richard, 2004; Vijayakumar, Murthy, & Khan, 2006; Yiotis, 2008). Each repository requires an efficient method for data transfer from sources in various locations. Most repositories implement the Open Archives Initiative Protocol for Metadata Harvesting[8] (OAI-PMH) (Ramirez, Dalton, McMillan, Read, & Seamans, 2013; Vijayakumar, Murthy, & Khan, 2006; Yiotis, 2008). Nevertheless, other protocols ale also in use like Really Simple Syndication, Simple Web-service Offering Repository Deposit, the Atom Publishing Protocol, and others (Ramirez, Dalton, McMillan, Read, & Seamans, 2013).

The objective of this work is to briefly outline the main assumptions and challenges, which occurred when introducing the national repository of theses in Poland. More specifically, we discuss the legal basis and other conditions of the repository, its architecture, implemented business processes, and some the most interesting technical details and performance statistics. We have to note that an information system implementing the repository is a part of the information system for science and higher education in Poland (Protasiewicz, Michajlowicz, & Szypke, 2016).

The novelty of this study lies in describing a Polish case study, sharing comments and remarks regarding development and deployment of the information system, and showing interesting statistics of the working software. They may be particularly valuable if we consider possible disasters that could occur during development or maintenance period of ETDs like data loss (metadata, full text, administrative data), backup failures, insufficient security policies, wrong architectures, etc. (Perrin, Winkler, & Yang, 2015).

This paper is structured as follows. Section 2 contains the introduction and related works. Section 3 explains the legal bases and other assumptions of the national repository of theses in Poland. The architecture of an information system implementing the repository covers Section 4; whereas, its business processes are discussed in Section 5. Technical and performance details are included in Section 6. Finally, conclusions and references are presented.

3. THE LEGAL BASIS AND ASSUMPTIONS

In 2014, The Law on Higher Education in Poland (The Act of 27 July 2005) was modified introducing in the Article 167b the national repository of theses. According to this, the repository is led by the Ministry responsible for higher education. It has to include all written master, bachelor, and engineer theses finished after 30th September 2009. A thesis record transferred to the repository must include:

- a title;
- the names of a thesis author or authors, a supervisor, and reviewers;
- the names of a University and its department (unit), where the thesis was defended;
- the exact date, when the thesis was defended;
- a name of a study field of the thesis author;
- a full content of the thesis.

Each thesis must be stored in the repository immediately after a student had passed his final diploma exam. It is the responsibility of a relevant university.

Based on the above, we can conclude that there should exist a central information system implementing the national repository, where all theses would be stored and processed. Each University must have access to the repository. We assume that most Universities should have a local

[1] http://www.dspace.org

[2] http://www.eprints.org

[3] https://theses.lib.vt.edu/ETD-db/index.shtml

[4] http://www.greenstone.org

[5] http://digitalcommons.bepress.com

[6] http://www.kobv.de/entwicklung/software/opus-4

[7] http://dlibra.psnc.pl

[8] https://www.openarchives.org/pmh

repository of theses produced by their students. Thus, the most convenient for the Universities would be permanent integration their systems with the central repository through interfaces like web services. However, some of them may have insufficient resources or only a few students so that integration could be economically unfounded. In that case, the national repository should provide a web application allowing manual operations on data (Figure 1).

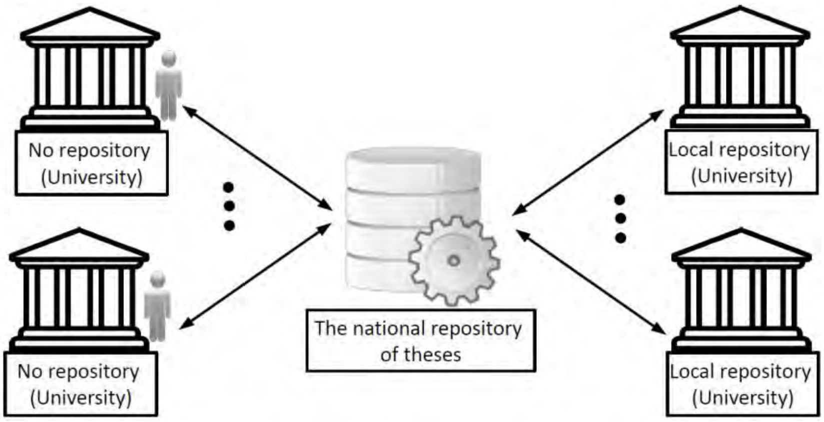

Figure 1. The overall idea of the national repository of theses.
(there are used incons from http://icons8.com)

4. ARCHITECURE AND BUSINESS PROCESSES

The repository architecture is based on the same assumptions like many modern information systems. First of all, it consists several layers separating different levels of data abstraction and various operational purposes, namely (i) a storage tier, (ii) a data access level, (iii) a processing layer, and (iv) a interfaces layer (Figure 2). Likewise in a typical information system, the data access layer provides access to data and, at the same time, it separates business operation carried out in the processing layer from raw data located in the storage layer. In the same manner, the processing layer is responsible for all computations, data validations, and handling clients' requests, and concurrently, it separates customers from accessing data available in the data access layer directly through user's interfaces.

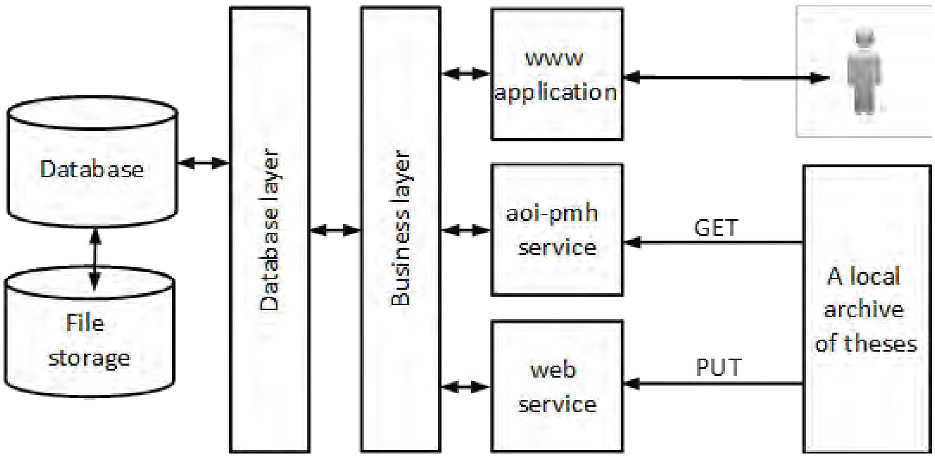

Figure 2. The architecture of the national repository of theses.

On the other hand, we introduce some important improvements of the typical architecture of an electronic theses and dissertations repository. Firstly, the storage layer is composed of a relational database and a file storage, which cooperate with each other. The database persists metadata describing theses, whereas the file storage handles theses' contents. Such solution provides quick search by using database mechanisms and fast access to thesis contents by using native file system mechanisms (for details, see Table 2 in Subsection 5.2). Since the amount of data in such repositories is usually very large, this dual storage solution allows organizing cheap backup processes instead of expensive commercial approaches.

Secondly, the interface layer comprises three submodules, namely (i) a www application, (ii) put and (iii) get services, which handle different types of client's requests (Figure 2). The web application allows manual storing, updating, and browsing data. It is very helpful for small universities with a small number of students or when accidental updates are needed. Contrary to the www application, which is dedicated to humans, both service types are designed to integrate the national repository with the repositories of theses located in universities. A web service based on Representational State Transfer (REST) architecture implements a PUT operation, which means that a client in a local repository actively puts data into the central repository. The client sends a ZIP file comprising an XML file with metadata describing theses and the files containing theses' contents. Opposed to the REST service, a service based on Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) implements a GET operation. It actively harvests theses from the local repositories if they provide an appropriate interface and are registered in the central repository.

5. TECHNICAL DETAILS AND PERFORMANCE

The repository had been developed in 2013[9] and deployed in the fall of 2014[10] as the part of the Information System for Science and Higher Education in Poland (Protasiewicz, Michajlowicz, & Szypke, 2016). Since that time we gained much experience regarding maintenance a vast repository of theses, which we are going to share in this section.

5.1. Implementation technologies

The system has been developed in the Java Enterprise Edition[11] (JEE) technology with the use of Maven[12] tools and the Spring[13] framework. Especially, we used Spring components like Core, Security, Model View Controler, and Data Java Persistence API. An interface layer is based on Java Server Pages (JSP), jQuery[14], and Spring components, which are included in the business and database layers, as well. Additionally, the business layer utilizes a Google library for Java named Guava. Data are stored in a MongoDB[15] database version 2.6.x and a Linux file system.

5.2. The case of MongoDB vs filesystem

Initially, all repository data were stored in a MongoDB database version 2.4.x. However, the performance tests indicated that this database was inefficient due to excessive lags during writing data on a physical storage system. Thus, we tried to upgrade the MongoDB database from version 2.4.x to 3.0.x containing an improved storage engine named Wired Tiger. Unfortunately, we encountered too many obstacles during this operation. In that time, the database software was unstable, and it contained many open issues. Additionally, it was hard to find professionals in this technology, or they were too expensive for us likewise an official support.

The troubles mentioned above led us to attempts in finding other solutions. After preliminary experiments, we decided to use a really straightforward and convenient solution. We left all metadata in the MongoDB database, whereas the entire content of theses was moved to a filesystem. For example, almost 70,000 theses retained in the filesystem were processed about 5

[9] The first version of the repository was developed in 2013 by Interdisciplinary Centre for Mathematical and Computational Modelling, University of Warsaw; however, this software was never deployed publicly.

[10] The repository was redesigned and deployed publicly in 2014 by National Information Processing Institute, Poland. More or less, it is the currently running version of the software.

[11] http://www.oracle.com/technetwork/java/javaee

[12] https://maven.apache.org/

[13] https://spring.io

[14] https://jquery.com

[15] https://www.mongodb.com

hours faster than those stored in the MongoDB. Table 1 covers the small excerpt of the empirical results confirming this observation.

Table 1. The comparison of processing times with regard to different data stores, i.e., (i) whole data are stored in the MongDB database version 2.6.x, (ii) the MongoDB covers metadata, and the theses are stored on the Linux filesystem.

Datastorage	Number of theses	Time start	Time stop	Duration
Metadata→ MongoDb 2.6.x Content → Filesystem	67,379	04:11 9:00	05:11 4:44	19h 44m
Metadata and Content -→ MongoDb 2.6.x	69,451	09:30 9:00	10:01 11:05	25h 5m

The fields describing theses are covered in Table 2. As we mentioned before, they are persisted as metadata in the database. Thus, we can easily query the repository by various values of these fields and, based on fast indexes, quickly show the relevant results on the users' interface. The thesis content is loaded from the file system only if it is requested by users.

Table 2 . The fields in metadata, their quantity, and types.

Field in metadata	Quantity	Data type
Thesis title	1	String
Keywords	0…n	String for each keyword
Thesis authors – first, second, and family names	2…n	String for each name
Thesis supervisors: first, second, and family names	2…n	String for each name
University and department names	1	String for each name
Date of work defense	1	Date
Obtained professional title	1	String from a dictionary, e.g., engnieer, master of science, master of art, etc.
Name field of study	1	String

Additionally, we considered a MongoDB shared cluster, but it required too much hardware in comparison our means. Eventually, we decided to use the upgraded version (2.6.x) of the MongoDB database for metadata and the simple Linux file system for all theses files. In our opinion, this solution is cheap and fast enough for our purposes, e.g., cooperation with a plagiarism system. Nevertheless, the plagiarism issues are outside the scope of this work. We expect influx about 1.2TB data each year and believe that this storage would handle these data without any problems. We have to note that there are no particular reasons for using a NoSQL database like MongoDB for storing metadata. It could be any (relational or object-oriented) database. We still operate the MongoDB database due to too high costs of refactoring to another database.

5.3. Usage statistics

The all statistics presented in this subsection represent the state of the national repository of theses on February 20, 2017. By this date, the repository has covered over 1 million theses and approximately 3.5TB of data. On average, a thesis size is equal to 3.7MB. However, it varies from 2MB to 8MB depending on a university type or its category (Table 3 and Table 4).

Table 3. An average size of theses in respect to university types.

Type	Average thesis size [MB]	Percentage of theses [%]
University	3.021	53
Technical University	8.246	3
Medical University	2.344	5
Other units	3.225	39
Average	3.717	

Table 4. An average size of theses in respect to university categories.

Category	Average thesis size [MB]	Percentage of theses [%]
Public	3,901	79.7
Non – public	3,079	18.7
Catholic	2,112	0.4
Others	2,010	1.2
Average	3,717	

As we mentioned in Section 4, there are three ways of storing data in the repository. Initially, we expected that the OAI-PMH service should be the most popular among clients as it is an open source protocol and widely known over the world. Surprisingly, the most common interfaces are the web application for manual operations by humans and the web service implementing the PUT operation for transferring data from other programs (Table 5).

Table 5. The usage of interfaces to sore data in the repository

Interface	Number of clients [%]	Percentage of theses [%]
Web application	75	42
OAI-PMH service	4	3
Web service (rest)	21	56

Table 6. Types of files stored in the repository

File type	Percentage [%]
Portable Document Format (pdf)	57.0
Micosoft Word (doc, docx)	35.2
Image (jpg, png, tiff)	2.9
Text (txt)	1.1
Rich Text Format (rtf)	1.0
Compressed (zip)	0.7
Open Office (odt)	0.5
AutoCad (dwg)	0.3
Microsoft Excel (xls, xlsx)	0.2
Others	1.5

Usually, theses in the repository are in pdf or doc/docx format. However, we allow other file types. It is important, because a thesis may be composed of many files, e.g., the main dissertation is in pdf/docx, and there are additional images explaining experiments or files covering supplementary projects (Table 6).

6. CONCLUSIONS

In this study, we briefly outlined the main assumptions and challenges, which we encountered when introducing the national repository of theses in Poland. We tried to share our experiences regarding development and deployment of the information system. Particularly interesting is the fact that a data storage based on a filesystem turned out to be better than a NoSQL database. The low popularity of the OAI-PMH protocol among clients is another surprising fact. Presented in this article comments and remarks regarding development and deployment of the information system and selected statistics of the working software may help other parties to improve their repositories or take a decision regarding new solutions. The further work should explore in more details an optimal architecture of an electronic theses and dissertations repository, which must satisfy the criteria of fast information processing, easy datastore expansion, and low maintenance costs.

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simpleArchive – Making an Archive Accessible to the User

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Keywords
eScience, RDM, long term archive, service oriented architecture, PID

1. SUMMARY

At RWTH Aachen University a project aims at improving the support and technical infrastructure for Research Data Management (RDM). In this project the need was identified to provide researchers with a tool to simply upload and save files in a long term archive. Our solution allows the researchers to use a web interface to deliver their data as a single file into a tape archive. All uploaded artifacts are identified using a PID.

2. BACKGROUND

There is an initiative to set up an integrated Research Data Management (RDM) system within the next years at RWTH Aachen University. A project group focuses on consulting and training as well as on the development of technical solutions for RDM (Eifert, Muckel, & Schmitz, 2016). Since managing data requires extra effort from researchers, usability and seamless integration into existing workflows are key to establishing an integrated RDM. Technical solutions need to cover all domains of the research process: private and collaborative domain, in which researchers actively work with the data, as well as the archive and publication domain, in which data is accessed less frequently.

Long term data storage is becoming more and more important as research funding organizations require researchers to make their data available and re-usable (RfII – German Council for Scientific Information Infrastructures, 2016). At RWTH Aachen University archiving data using the IBM TSM client requires technical expertise that not every researcher has. Therefore, the goal of simpleArchive is to allow researchers to access long term archival capabilities without technical knowledge by way of a Software as a Service (SaaS) that uses state of the art web technologies. Archiving a file for the user is as simple as uploading a file on a web page.

3. OUR SOLUTION

The web interface presented by simpleArchive can be used to upload the research data to be archived. The data is then temporarily stored on a server before being transferred into a tape archive where the data can be stored for long terms at relatively low costs. The actual archival process is transparent to the user. Immediately after the user has completed the upload of the data a PID is issued which in turn may be used for referencing the data in a text publication or on a web page.

To restore data from the archive the researchers use the PIDs issued to identify their data. Using simpleArchive they can request to restore the data which is then copied from the tape archive to a temporary file store. Based on the temporary file a download URL is generated that the researcher can use to access the archived data. The URL is provided using the download mechanisms of GigaMove (Bischof, Bunsen, & Hinzelmann). This especially means that the restored data is only accessible temporarily using the URL. Afterwards the restoring process needs to be triggered again.

Additionally to the uploaded data, the researcher's affiliated institution is saved. If the researcher retires or leaves the university, it is then possible to name the institution responsible for the data. This is especially important since long term archives likely need to be migrated several times. Therefore it is desirable to save only data that is still relevant. A full process defining how data can actually be evicted from the archive, however, remains to be discussed.

Furthermore, if the PID is obtained by other researchers an anonymous landing page allows them to get in touch with the researcher who archived the data. Using the restore process described above the download URL can then be passed to allow access to the data within a community of researchers.

The web services used by simpleArchive are integrated into the existing infrastructure for personalized web services (Politze, Schaffert, & Decker, 2016). It is furthermore becoming part of an integrated service layer supporting the researcher throughout the research process. The integrated service layer depicted in Figure 1 merges different IT services used by the researchers.

4. CONCLUSION AND OUTLOOK

Basing the API on the processes rather than the underlying services effectively reduces the impact of vendor lock in. This design allows to add new services or to scatter requests between multiple services based on certain rule sets. This actively decouples the systems into smaller functional units, which in turn increases maintainability. Furthermore, this allows granting access to the service as part of a cooperation with other institutions or universities.

A generic metadata web interface is also part of the integrated service layer and allows the researcher to describe the uploaded data. Currently the collected metadata is saved as a RDF file. While this file can be downloaded and reviewed by the researcher the whole metadata library is not queryable as such (Politze & Krämer, 2016). A future project will consider different techniques, using triple stores to create an interactively queriable interface for the researchers.

This service oriented architecture organizes the access to the backend systems using vendor specific or legacy APIs. Basing the API on the processes rather than the underlying information services effectively reduces the impact of vendor lock in and therefore makes future migrations to proceeding systems easier. Furthermore, this design allows to add further information services or to scatter requests between multiple systems based on certain rule sets. This actively decouples the systems into smaller functional units, which in turn increases maintainability.

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Extending OAuth2 to Join Local Services into a Federative SOA

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Keywords
BYOD, SOA, OAuth2, federated services, eScience, eLearning

1. ABSTRACT

New approaches to teaching and research require machine readable interfaces as provided by service oriented architectures. Many scenarios in teaching as well as in research demand cooperation between members of universities. Identity federations and federated applications provide some means for collaboration. Current federation services for single sign on however are not compatible with common applications arising from service oriented architectures. The OAuth2 workflow allows personalized access to service oriented architectures for applications but lacks a definition for federated deployment. The presented extensions are based on the current implementation of OAuth2 They allow establishing a federation of OAuth2 token services that builds on top of the existing federated infrastructures in higher education.

2. INTRODUCTION

For funding and research organizations as well as governments, cooperation between universities and research organizations became a mandatory requirement. As projects are involving more cooperation, especially over long distances, supporting IT services are becoming more important. After all, many IT services that were exceptional five or ten years ago have emerged to be a part of the daily life for universities' members: students, researchers and employees alike. Consequently, universities want to rise their attractiveness by offering more innovative IT services.

Closer collaboration between researchers of different origins means increased mobility and in turn requires IT services to be transitive between organizations. Consequently, also funding for IT infrastructures and services converges to competence centers offering elaborated services in regional, national or even international federations (RfII – German Council for Scientific Information Infrastructures, 2016). Local providers have often swiftly tailored offered services to existing processes. Federative services, however, are often more basic and therefore may require levels of adoption to replace local infrastructures.

Ubiquitous access, standardized, machine readable and programmable interfaces (APIs) are becoming even more important due to the rising number of smart devices and data intensive applications: Not only in scientific context but also as parts of every users' daily routines. The Horizon report, one of the most regarded studies concerning the development of education lists Mobile Learning, Internet of Things and Artificial Intelligence among the six most important developments in higher education in the coming years (Adams Becker, et al., 2017).

Federated IT services, especially web applications, are available but most do not offer, APIs for the user to integrate services into local processes. Clearly one of the reasons is that, apart from some local implementations, the current federative authentication and authorization infrastructure (AAI) often does not offer out-of-the-box solutions for securing APIs and identifying users. Using the existing infrastructure, a set of extensions to the OAuth2 workflow aims to lift authorizations to the federated level.

3. RELATED WORK

Identity federations are well established and widely used to secure internet applications in educational and scientific context. These federations offer single sign on capabilities and allow exchanging user information between participating services (Grabatin, Hommel, Metzger, & Pöhn, 2016). National federations organize hierarchically to inter federations such as eduGAIN on a worldwide level. This does not only provide a standard way to authenticate users but also allows easy sharing and reuse of services across universities and other organizations. The underlying Security Assertion Markup Language (SAML) protocol (Cantor, Kemp, Philpott, & Maler, 2005) combined with its most widely deployed implementation Shibboleth (Knight, et al., 2014) however is technically restricted to interactive sessions in a web browser. Other applications, like apps installed on a smartphone require additional protocols.

Other software suites like OpenID Connect are more widespread in commercial applications. Major IT companies like Google, Microsoft and PayPal offer complying endpoints. OpenID Connect uses the OAuth2 workflow as a basis to exchange user information and to provide sign on capabilities for remote services (Sakimura, Bradley, Jones, Medeiros, & Mortimore, 2014) and thus allows usage beyond web applications. The underlying workflow is easier to understand than SAML, which leads to a decent fragmentation of client and server implementations supporting OpenID. While the specifications imply a certain security, recent analysis of applications revealed that many applications are prone to security problems due to implementation errors (Li & Mitchell, 2016). In the current specification, OpenID connect allows remote services to log in via a single identity provider or the service has to maintain a set of viable identity providers. There exists, however, a draft on how federations of several identity providers are realized using OpenID Connect (Hedberg, Gulliksson, Jones, & Bradley, 2016). While OpenID Connect uses the OAuth2 workflow, its intention is to authenticate users and not authorization for applications and web resources needed in the underlying scenario.

A prominent example of a federated service is the campus cloud “sciebo” (Vogl, et al., 2015). While the service itself is working properly, it shows where the current federation using SAML and Shibboleth fall short: upon first usage, users need to create a new account and set a separate password after authorizing via Shibboleth. The user then has to log on to the service using the newly created credentials. Nevertheless, this allows the user to use the file synchronization APIs of the software using the same credentials. Applications using the APIs for a user need to store these credentials. While users mostly accept this for locally installed applications, this is legitimately uncommon for third party applications that want to integrate sciebo into existing processes. In addition, lifecycle management of eligible user accounts is an issue. The system therefore requires a login via Shibboleth every six months to identify old user accounts.

Several single universities approach interfaces that integrate existing systems into new applications for their students and employees. The works of Mincer-Daszkiewicz and Barata et al. show two practical examples of APIs in the field of university administration (Mincer-Daszkiewicz, 2014) (Barata, Silva, Martinho, Cruz, & Guerra e Silva, 2014). The architecture presented by Politze et al. generalizes for several personalized eLearning applications but aims to cover more university processes (Politze, Schaffert, & Decker, 2016).

Together with the project STApps Lehmann et al. have developed Viadrina Core, a middleware that abstracts data from student lifecycle management into a generic interface that can be used across university boundaries, for example in a federation, but has currently no means to identify users (Lehmann & Huber, 2015).

The goal to offer web services for eLearning and eScience basing on existing AAI federations is the starting point for this extension of the OAuth2 workflow.

4. THE CURRENT OAUTH2 IMPLEMENTATION

The OAuth2 workflow as described in RFC 6749 (Hardt, 2012) allows secured, personalized access to web services or resources and handles the user’s authorization without supplying credentials to the application itself. This also paves the way for third party developers accessing central IT services. Generally, it follows the steps 1-4 shown in Figure 1.

At first, the user accesses the application (1). To access the web service resources for the user the application needs an access token. It directs the user to the token service passing along a set of scopes

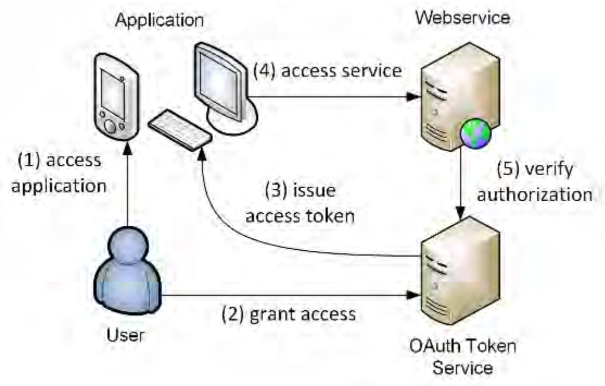

Figure 1: Schematic of the OAuth2 workflow

that defines which services to access. The token service then requires the user's credentials before granting access for the application (2). The token service then issues the access token (3). The application can now use this token to access the web service resources (4). Upon incoming requests, the web service has to verify the authorization (5). Due to tight coupling of web services and the token service, this step remains mostly internal. To decrease coupling of the services, modelling of this step is key for a cooperative scenario where multiple web services access a single token service.

Detaching authorizations and token handling from the business logic allows decentralization of services within a cooperation. All web service resources, however, are able to process the same tokens. The user has to authorize an application only once and not for every service in the cooperation which is a requirement for seamless integration of APIs into one application.

In terms of operability and security key implications of this model are:

- *The token service is the authority*
  Within the OAuth2 workflow, the token service clearly identifies as an endpoint for all redirections of the user and backchannel communication of web services.
- *The token service is trusted*
  Both the users and web services know and trust the token service. Users trust in the service to authorize applications only with their consent. Web services trust that the authorization information provided by the users is legitimate.
- *Users are known*
  Verifying the authorization only transfers minimal information about user context of the application. Web services have to determine the user's permissions to access certain resources.
- *Applications and web services are separated*
  Applications rely on resources provided by web services. Web services however should only rely on their own data about the user rather than requesting other resources of other web services. Thus, security issues as mentioned by Yang et al. (Yang, Lau, & Liu, 2016) are reduced.

Apart from providing the pure functionality, when lifting OAuth2 based SOAs from a local cooperative scenario to a federated scenario, it is crucial to address concerns arising from these implications.

5. ADAPTING OAUTH2 TO THE FEDERATIVE SCENARIO

The adoption of OAuth2 should of course consider already established national and international AAI federations. Furthermore, the OAuth2 workflow should not replace existing parts of the infrastructure, but extends them and to enable authorization of applications. Before granting access to an application, the user needs to supply credentials in order to log in. Integrating the token service as a service provider into the federation allows using sign on capabilities of the existing federation.

In a very centralized scenario, a federation could simply set up one authorization server. By looking at the key implications from the previous section, even this simple scenario reveals challenges of federative authorization:

- *The token service is the authority*
  Since only a single instance of the token service exists, it remains the authority for all interactions with the user and backchannel communication.
- *The token service is trusted*
  The organization behind the federation provides the token service. Local implementations may be trusted more. In addition, there may be issues with someone else managing authorizations for local users.
- *Users are known*
  In federated scenarios, this is generally not the case. The authorization needs to convey additional user information.
- *Applications and web services are separated*
  The security considerations from the cooperative implementation remain the same. The federation has to endorse service providers and application developers to use the workflows correctly.

Even though this solution is simple, two problems arise: (1) Setting up only a single authorization server, subverts the idea of many federations and their members to remain responsible for their own set of users. Consequently, the infrastructure should remain decentralized and allow each member of the federation to provide their own token service. (2) Additionally federated services usually do not meet the condition to know users in advance. It might thus be necessary to deliver a more detailed set of information about the user.

5.1. Providing Decentralization

In a second approach, several authorization servers exist in the federation. Either Users or web services need to establish a trust relationship between them and every single authorization server. In a case where users use different token services based on the resources they want to access applications might require authorizations from multiple servers and usage of web services across organization boundaries is hardly possible. In case of web services, this would require to keep a list of trusted authorization servers. A federation then is required to keep an additional directory of authorization servers. Many commercial services implement the one or the other pattern using accounts and token services of Google, Facebook, GitHub or the like by maintaining their own list of trusted services. Considering that the German federation DFN-AAI-Basic already consists of 230 identity providers this seems hardly possible.

A third approach tries to make better use of the existing federative infrastructure. The general idea is that users and web services will always interact with their local authorization server. The authorization server then handles the communication and redirection to other peers to start or verify an authorization. Users and web services keep the local authorization server as the authority; in turn, the authorization server then establishes the trust relationship to the remote server.

Either way, the federation has to maintain a directory of authorization servers, possibly by extending existing metadata directories by token service endpoints.

5.2. Providing User Information

For most web services, it is most likely necessary to provide basic user information. The existing federations participating in eduGAIN already address this second issue. Table 1 shows the results of a survey on the published metadata of the German DFN-AAI federation. The table shows the number of times a service provider requires a certain attribute. Being able to serve the top attributes generally should suffice for services to be able to establish the user context. Apart from user information like `displayName` or `mail`, attributes from the `eduPerson` schema obviously have a high relevance.

Existing federations clearly define these attributes and the service providers accessing them. Technically conveying the information as such is simple. It should however be noted that some of these attributes like `mail`, `sn` (surname) or `givenName` are personal data which should not be shared with relaying parties without the users consent. Furthermore, operators of identity providers need to verify that requested attributes are legitimate and sometimes enable them upon request for single service providers. Again, federations and local operators already acquire this information. Extending the

Table 1: Attributes required by 347 service providers in the German DFN-AAI federation

Attribute	Count	Attribute	Count
eduPersonPrincipalName	167	persistentId	10
mail	117	eduPersonUniqueId	7
eduPersonScopedAffiliation	80	schacHomeOrganization	6
sn	73	schacHomeOrganizationType	3
givenName	67	schacPersonalUniqueCode	3
eduPersonEntitlement	63	bwidmOrgId	1
eduPersonTargetedID	37	eduPersonOrgUnitDN	1
cn	18	eduPersonPrimaryAffiliation	1
uid	18	ou	1
displayName	14	dfnEduPersonTermsOfStudy	1
eduPersonScopedAffiliation	13	uniqueIdentifier	1
o	12		

service provider metadata by the OAuth2 scope used by the web service allows distribution of this information in the federation.

6. IMPLEMENTATION OF FEDERATED OAUTH

Based on the findings specified in the previous sections, it is now possible to deduce a recommendation on how to implement an OAuth2 federation to comply with the existing federative scenario. Using the key implications, the proposed solution is evaluated:

- *The token service is the authority*
  Every local token service is the authority. They are the only *token* service known to users and applications. Users use a single token service to manage their authorizations.
- *The token service is trusted*
  Users and web services only trust their local token service. Federative metadata established trust between local and remote token services.
- *Users are known*
  A small set of attributes from existing federations is contemplable. Transferring them during validation provides user information.
- *Applications and web services are separated*
  The federation hast participating token services, web services distributes metadata needed to connect the services. Applications remain subject to local administration. This effectively separates services and applications.

Federative authorities are then required to keep directories of participating token and web services, reusing existing infrastructures. However, the presented findings are merely a first step towards actually establishing a federation of OAuth2 service providers. Starting from the presented model it is now possible to deduce a proposal for implementation

Figure 2 shows an overview of the participating parties and necessary communication in this workflow. Bold arrows show parts additionally needed by the federative workflow when compared to the initial workflow. These three steps, token service resolution during authorization and validation (1), token issuing (2) and remote token validation (3) therefore need closer investigation.

6.1. Token service resolution

When a user wants to authorize an application, the application redirects to the token service within its organization. This token service can then validate the legitimacy of the application and then

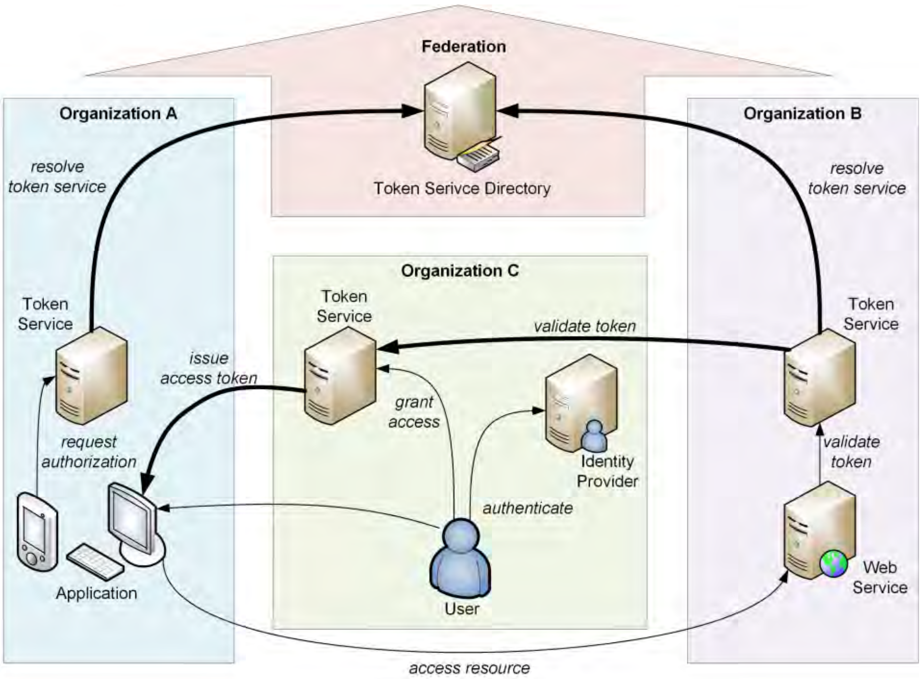

Figure 2: Schematic of the federated OAuth2 workflow

accesses the token service directory offered by the federation. For each token service in the federation, this directory should at least contain:

- *Name of the token service*
  Much like in current federative scenarios, during authentication, the user has to determine a home organization. This name should serve as a hint to find the correct organization.
- *Namespace of the token service*
  The eduPerson scheme offers several attributes, which are unique within a namespace (scoped). This namespace determines valid scopes of a token service. Comparing `eduPersonTargetedID` and `eduPersonPrincipalName` it is obvious that different kinds of techniques are used. While `eduPersonTargetedID` uses the entity ID of the identity provider, the service provider and a unique id to form a three tuple, `eduPersonPrincipalName` and other scoped attributes make use of a postfix in the form `user@namespace` (Internet2, 2012).
  In the OAuth2 federation, this namespace also applies to separate applications and web services connected to the different token services.
- *Signing key of the token service*
  While local services and their respective token services generally have a strong trust relationship, public key cryptography leverages trust among token services. By signing messages with these keys, token services confirm the authenticity of requests.
- *Endpoints of the token service*
  The five endpoints already used by the cooperative OAuth2 workflow support various authorization flows:
  - o The *Authorize* endpoint authorizes tokens for server side and web applications.
  - o The *Code* endpoint to request authorization codes that shown to the user used for installed applications.
  - o The Token endpoint to manipulate access tokens during and after the authorization process. This includes extending the lifetime of the token or invalidating a token.
  - o The *TokenInfo* endpoint supplies information about a token. Application should verify that the token is valid and actually belongs to the application.
  - o The *Context* endpoint for other token services validates tokens and resolves user attributes.

According to the already existing conventions in the OAuth2 workflow, this directory could be encoded as a JSON file hosted by the federation. A single file therefore may include all token services in the federation. The format leaves room for later additions and metadata added by the federation:

```
{
  ...
  "token_services" : {
    "https://oauth.example.com" : {
      "displayName" : "Example University",
      "namespace" : "example.com",
      "key" : "-----BEGIN PUBLIC KEY-----\nMIGfM...",
      "endpoints" : {
        "authorize" : "https://oauth.example.com/authorize",
        "code" : "https://oauth.example.com/code",
        "token_info" : "https://oauth.example.com/token_info",
        "context" : "https://oauth.example.com/context"
      }
    },
    ...
  }
}
```

6.2. Token Issuing

After the user selected a home organization, the token service signs the authorization request and, depending on the authorization flow, redirects the user to the home token service or relays the response to the application that in turn redirects the user. The users' home token service validates the signature and starts its authentication workflow. The user may now log in and grant access for the application. Based on the currently used workflows for authorizing installed applications (e.g. apps on a smartphone) and web applications additions to the workflow arise:

In the device workflow, the token service issues a temporary device code and a user code as in the sample below. The user then has to enter the code on a web page. For devices that do not have rich input abilities the user has to copy the verification URL and user code manually to a computer. Many devices, like smartphones, offer to open a web browser directly. If the user still has to copy a code, this results in very bad usability.

```
{
  "device_code" : "BaUAJHPFYFi6wKU0WY5xLC",
  "user_code" : "SFW7WZXK7G",
  "verification_url" : "https://oauth.example.com/verify",
  "expires_in" : 1800,
  "interval" : 5
}
```

In order not to undermine cases where the user has to type the verification URL, it should remain as short as possible. Allowing user friendly transmission of the code, token services should however also accept URLs of the form:

```
https://oauth.example.com/verify?user_code=SFW7WZXK7G
```

In contrast to the device workflow, the web application authorization obviously requires a web browser. It relies on HTTP redirects and ends by directing to a page of the application. For the security of the OAuth2 workflow, it is very important that the last redirection URL actually is valid for the application since authorization tokens could otherwise be hijacked. The user's home organization however does not know the application in this case. The token service in the applications organization therefore has to verify that the redirect URL actually belongs to the application prior to signing and redirecting the authorization request.

In order to identify the token service that issued the token, it should also include the namespace of the token service in the form `token@namespace`.

6.3. Remote Token Validation

When accessing web service resources, applications pass the authorization token. As in the cooperative workflow, the web service validates the token against the token service in its own organization. The token service validates the request and its origin. Using the namespace, the token service can now resolve the user's home organization and the associated token service. The token service signs and then forwards it to the remote token service.

Using the signature, the token service in the user's home organization, is able to validate that the request is legitimate. It verifies, furthermore, that the token is actually valid. Additional attributes to establish the user context at the web service complete the response. By default there should be at least one attribute uniquely identifying the user for the service. The aforementioned `eduPersonPrincipalName` therefore seems like a viable choice. Many services however need additional attributes, commonly `mail` or `givenName`. If web services require further attributes operators of the organization on demand can add them. Based on the findings in table 1 and if compatible with local privacy conventions a "zero configuration" attempt for locally unknown web services the three mentioned attributes accompanied with `eduPersonScopedAffiliation` are a tradeoff to reduce the need for manual intervention.

A valid response from the token server of the user's home organization in JSON format could look like this

```
{
  "isValid" : true,
  "application" : "ahcndwlsajcnalfejalsd@example.com",
  "mail" : "max.power@example.com",
  "displayName" : "Max Power",
  "eduPersonPrincipalName" : "anpqr7d@example.com",
  "eduPersonScopedAffiliation" : "student@example.com"
}
```

The token service receiving the validation of the token then needs to verify that all scoped attributes actually belong to the same namespace the token suggested. Only then, it should forward the validation response to the web service.

7. CONCLUSION AND FUTURE WORK

In order to complete the presented workflow, it is still necessary to address and fully define some security considerations. For example, the actual technology for signing responses and requests is still undefined. JSON Web Tokens (JWT) (Jones, Bradley, & Sakimura, 2015) seem like a natural choice. Furthermore, additional security measures may be necessary to protect the token service directory from manipulation.

A "zero configuration" policy like in the proposed implementation intentionally sacrifices strong privacy requirements in order to remain as simple as possible for application and web service developers but also for operators of the token service. At the current stage all applications, web services and token services are well known and go through the same privacy review. As the number of associated services increases, these policies should undergo a review. Still the threshold to access to this kind of services should be as low as possible to allow innovative ideas and concepts to focus on the core of their implementation. A strict separation of applications offered by third parties and web services offered by organizations is the starting point for a reasonable compromise between privacy and flexibility.

The presented extension of the OAuth2 workflow gives an example on how to integrate OAuth2 services into current federations. Analyzing the main challenges, *Token Service Resolution* and *Providing of User Data* yielded necessary information for the practical implementation. An implementation of the prototype is currently in review for bugs and security issues. Another project furthermore evaluates the prototype for joint services of RWTH Aachen University and Jülich Super Computing Centre. Further projects are in a planning phase. This furthermore underlines the importance to find a viable solution for personalized access to SOAs.

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eID & eIDAS at University Management - Chances and Changes for Security & legally Binding in cross boarder Digitalization

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Keywords
eID, eIDAS, electronic signature, legally binding, university management, TREATS

1. SUMMARY / ABSTRACT

Based on national eID solutions for university process scenarios this paper discusses eIDAS extensions with regard to chances, changes, benefits and challenges compared to eID.

2. Overview

Several initiatives in Europe are involved in the development of frameworks to improve student mobility. These aim at the harmonization of student data formats/forms and appropriate IT support for administrative procedures. Examples include the EUNIS task force for students mobility (formerly RS3G) or the Groningen Declaration Network or the Erasmus without Paper Project [11, 12, 25, 29]. Besides the standardization of forms and procedures security, privacy and legal binding of these is an important issue and hence discussed in this paper. The use of security functions like qualified signatures and the eID of the German national identity card (eID/PA or GeID/PA [2]) opened up new possibilities for the digitalization of legally binding processes in university management in Germany. Some of these innovations were developed within the projects "eCampus/Scampii" and "eID at universities" [20, 22, 23, 24], based on national signature and eID frameworks in Germany. Furthermore, chances and changes for security and legal binding by eIDAS regulation ([10], prepared by the STORK projects [14]) based extensions at university management are discussed in regard to the ongoing EU funded project TREATS (Trans European Authentication Services, funded by EU CEF Program).

3. Scope, Objectives, Results for electronic University Management

a1. A full digitalization of student mobility processes in EU aiming to provide security, privacy and legal binding for the relevant electronic process steps. This requires a certain level of interoperability across borders.

a2. Important electronic security functions to reach the goal state in a1 are (qualified) signatures, eID functions and encryption. However, there was a lack of interoperability in the EU concerning a cross border viewpoint, which then was regulated by eIDAS (EU, [10]).

a3. For public administrations in Germany (which includes Universities & Schools) the integration of eID online functionality of the German Identity Card (PA) as exclusive mean of access to an University web form enables filled in web forms to reach fully legally binding (presumed that the University as an eID application provider will use integrity means to secure the web form contents). This is an alternative to the use of qualified signatures. In addition the eID online functionality of the PA will offer a strong 2-factor double sided authentication scheme to users and service providers, including strong privacy. There are similar approaches in some other EU member states. These are strong foundations for the full electronization of sensitive university processes, like matriculation or diploma certification. eID applications for such purposes were developed in the projects eCampus/Scampii at HS Harz & MLU [20, 22, 23, 24] (also cross university domain boarders).

a4. The eIDAS regulation of the EU (based on former work, e.g. STORK [14]) offers a solid level of interoperability of remote and mobile trust services like (qualified) signatures, seals and of national eID functions across borders working at same security level. Therefore, sensitive process steps like user authentication at matriculation processes, legally binding processes or the security of diploma certificate documents (including notarization), could be reached single-handed by electronic means. Examples are under development at TREATS project [27].

a5. The concept of "interoperable Servicekonten" [4] (at this point still under ongoing evaluation) would allow the integration of strong eID/eIDAS authentication functions for new fully electronic application processes of pupils/students lifecycle at universities (e.g. for matriculation) or even for other qualifications in Germany. The electronic notarization of electronic copies of administration documents is allowed by federal law (§33 VwVfg [28]), but university regulations at local state law may require adaption here, e.g. for allowing electronic notarization of university diploma certificates (similar for school certificates).

4. Integrated Services

4.1. eTestate – eID registration & login for lab exercises

The eTestate application was the first eID based application at HS Harz to enable eID based registration & login for lab exercises for students in a fully electronical manner with strong two factor authentication, based on the eCampus architecture, as shown in [9, 21, 22]. Additionally, the lecturer was enabled to grade and sign the student results via qualified signature QES and to deliver it securely to the legacy campus management system HIS via OSCI egovernment standards and security gateways.

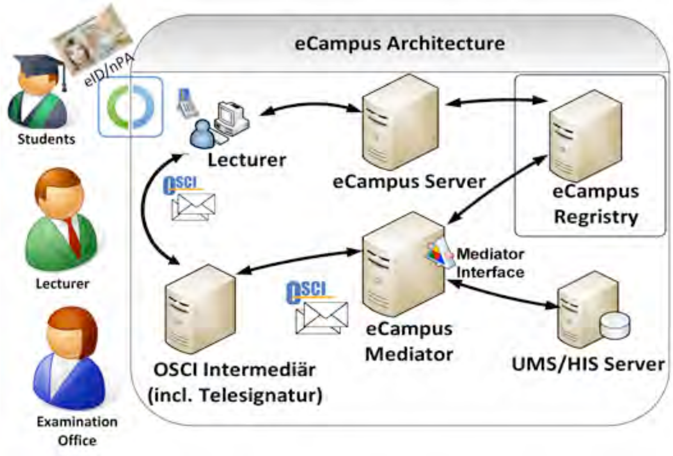

Figure 1: The eCampus security shell architecture, integrating GeID, OSCI, QES standards

4.2. MyCredentials - refreshing credentials remotely by eID

In case of loss of university credentials (like passwords or PKI certificates), the current policy at universities often requires the physical presence & authentication of the credential owner at the computer center of the university to apply for new credentials.

By using the eID function of the German ID Card (GeID), we recently enabled a remotely usable new eID based platform solution "myCredentials" to apply for new credentials by customers (which are pre-registered by eID at the platform).

The applied new credentials will be uploaded by the administrator in an encrypted manner to the mycredentials web site of the customer (e.g. via AES based ZIP archive encryption), a decryption enabling PIN will be transferred over a separate channel, e.g. via SMS to the smartphone of the customer, applied at the eID based website. Therefore, a strong protection for a confidential credential exchange (e.g. passwords, secret keys) will be established.

In the future this scheme could be extended to exchange other confidential documents in an effectively managed and analogously end-to-end secured manner by eID (using pre-encrypted key and document exchanges by eID), usable for multiple parties/customers (pre-registered by eID at the platform), without the need for additional PKI schemes/keys, This could be an interesting add-on feature for so called "interoperable Bürgerkonten" (interoperable public administration accounts for citizens and enterprises), which are planned in Germany [4, 15, 16].

Figure 2 shows the registration and login form for the MyCredentials site.

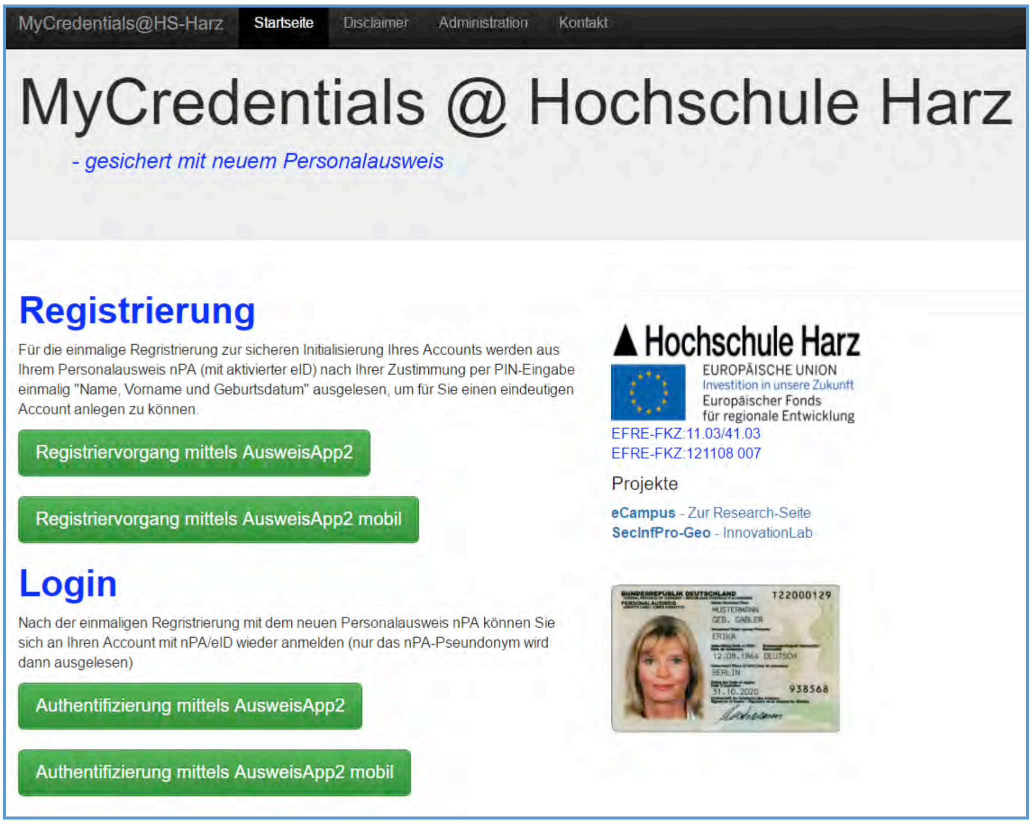

Figure 2: MyCredentials-Platform - Credential Security via eID/PA-Access

4.3. Web forms with eID access -- legally binding uploads for visitors

Web based Registration and Login by eID will be offered to visitors or partners of the university. Additionally an upload feature with combined remote qualified signing (QES) of the uploaded contents is available (as tele signature) with involved legally binding. Figure 3 shows the upload form.

This platform could also be used for application and matriculation of student applicants. If electronic certificates for higher education entry qualifications (qualified signed by schools) are allowed by law, then the whole process of matriculation could be implemented electronically.

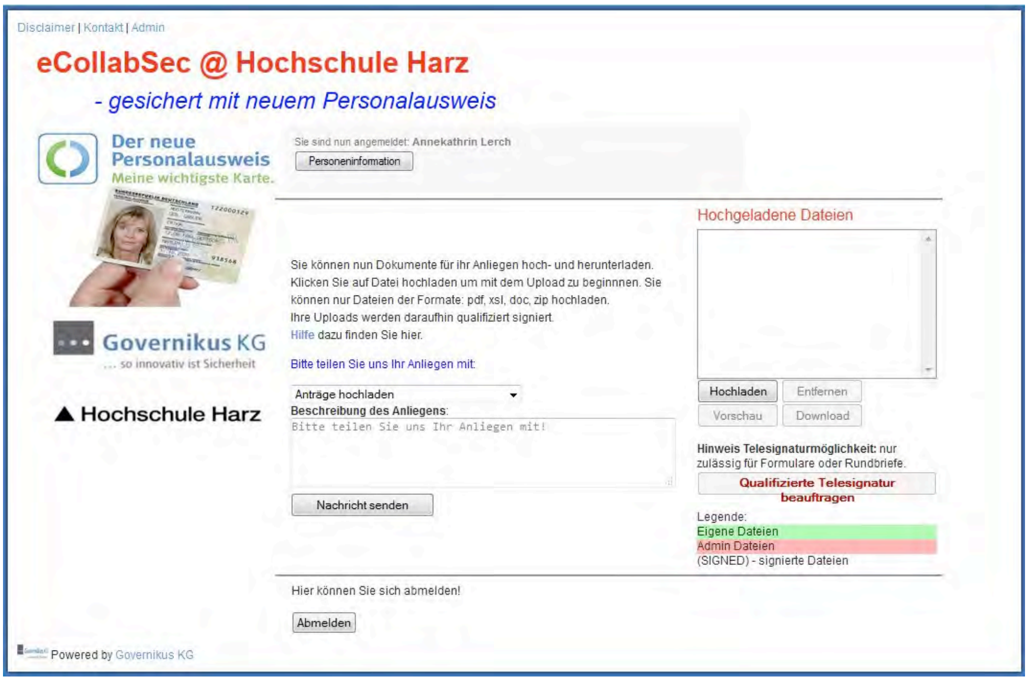

Figure 3: eCollabSec Platform - Security & legally binding via eID/PA

4.4. Electronic Diploma Certificate (copy) with enhanced privacy & integrity -- eID based diploma certificate checks via delegation by the diploma owner

As a variation of the visitors web site with eID the eDiploma Certificate will be configured. By using his eID, the graduated student could download here his qualified signed electronic diploma certificate (as an electronic copy to the paper based certificate). Additionally the graduated student will have the ability to delegate temporary read access rights to other parties (e.g. to a potential employer, to whom the graduated student made an application) by using access control rights. To improve privacy and traceability of the diploma certificate data, the owner could use quality reduction techniques such as reducing resolutions or producing a self-signed temporary watermark overlay - with specifically produced watermark for the granted accessor of the original diploma certificate data (which are signed by the university). For quality reduction and watermarking, the requirements should be investigated in more detail in the future and potential useful approaches selected. For example invertible watermarks combined with electronic signatures might be useful to reproduce also the original document if required, see work in [3, 7, 8, 13, 18, 26].

5. University cross domain eID applications

The federal administration office assigns eID certificate to access the information of identity cards in the domain of the specific eID application provider. An eID certificate assigned to one university offers access for more than one application but limited to the domain of the certificate owner. The limit prohibits a cross domain usage between universities. But access from domains of other universities are required for joint eID based services, therefor for enabling the legal base accordingly the local government university law of Saxony-Anhalt was changed [1].

To overcome the technical problems of the domain limitation, we use eID delegation with an eID proxy system analogous to the eduroam authentication. Figure 4 shows the test system and the eID extended communications (projects[1] "eCampus/Scampii" and "eID at Universities").

[1] Supported by European Fund for Regional Development ERDF (EFRE FKZ: 11.03-08-03)

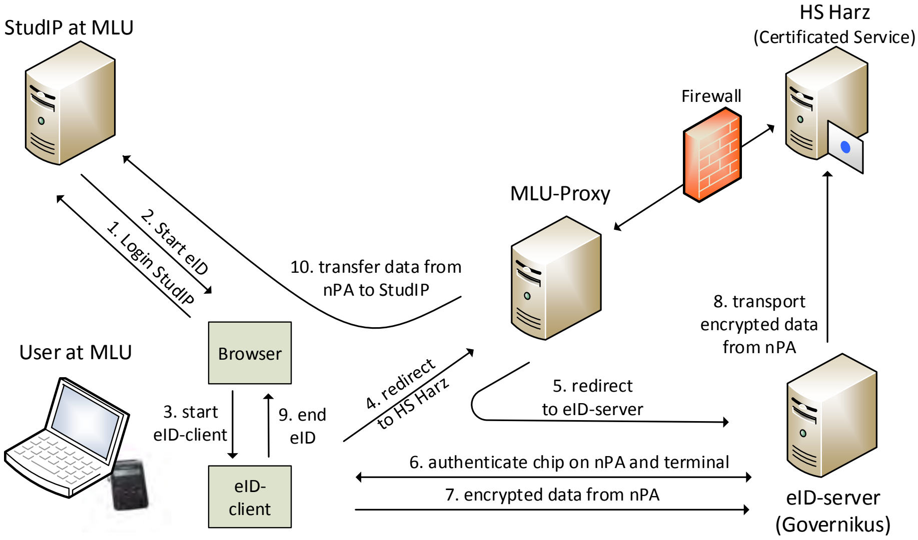

Figure 4: Cross domain university access with eID proxy test system

An example for cross domain authentication and authorization service is eduroam (education roaming). Eduroam offers secure network access, especially to WLAN, for matriculated student or researchers of foreign European universities and colleges when visiting an institution other than their own [5]. The authentication process is delegated by the RADIUS[2] protocol to the home institution of the user, which needs to be a part of the inherent domain hierarchy. As authentication factor a username password combination is used. To allow the authentication with eID cards we need cross domain access to the eID function.

eID allows alternative methods for delegated user authentication and authorization. Instead of sending authentication factors like username and passwords to the home institution only a distinct ID consisting of name and e.g. birthday will be transmitted. The reliable authentication factor is determined by the eID function from the ID card at the local institution. The mapping between the ID and person is made by the home institution.

To combine the advantage of reliable and strong eID authentication and fast challenge-response password mechanism we use the eID function only for the first authentication. A secret token is generated during the authentication process and stored on the device of the authenticated user, e.g. the laptop or smartphone. The token allows the challenge-response authentication for a limited time. After expiration a reauthentication process with eID is required.

6. **TREATS** (TRans-European AuThentication Services, by eIDAS)

Hs Harz is part of the ongoing project consortium TREATS to implement eID based infrastructure and applications according eIDAS in Germany (funded by EU CEF program 2015[3], s. [27]), which regulates the acceptance of "high" notified eID solutions from other EU member states at eID servers in Germany by September 2018. Hs Harz is going to implement eIDAS based eID access extensions for existing eID/PA applications in the fields of student mobility, researcher mobility & partnership and local eID/eIDAS campus infrastructure, see Figure 5 concerning R&D (ongoing work in TREATS). Indirectly only, and in a limited way, user uploads to these eID/eIDAS extended websites could gain a kind of local substitution of qualified document signatures, by eGovernment Laws, if these are

[2] RADIUS: Remote Authentication Dial-In User Service

[3] The sole responsibility of this publication lies with the author. The European Union is not responsible for any use that may be made of the information contained therein.

applicable for universities. But in the future, for a fully legally binding cross boarder, because of eIDAS regulation, additionally the integration of eIDAS/eSignatures/eSeals would be required. While (federal) administrative procedure laws (e.g. Verwaltungsverfahrensgesetz [28]) would allow to produce electronic document copies with electronic signatures and notarizations of the issuer administration, accordingly at local government university law some extension may be required [1]. Because of ongoing law adjustments in Germany (e.g. because of eIDAS and other regulations), accordingly here may be some important scope of designs with importance for university procedures.

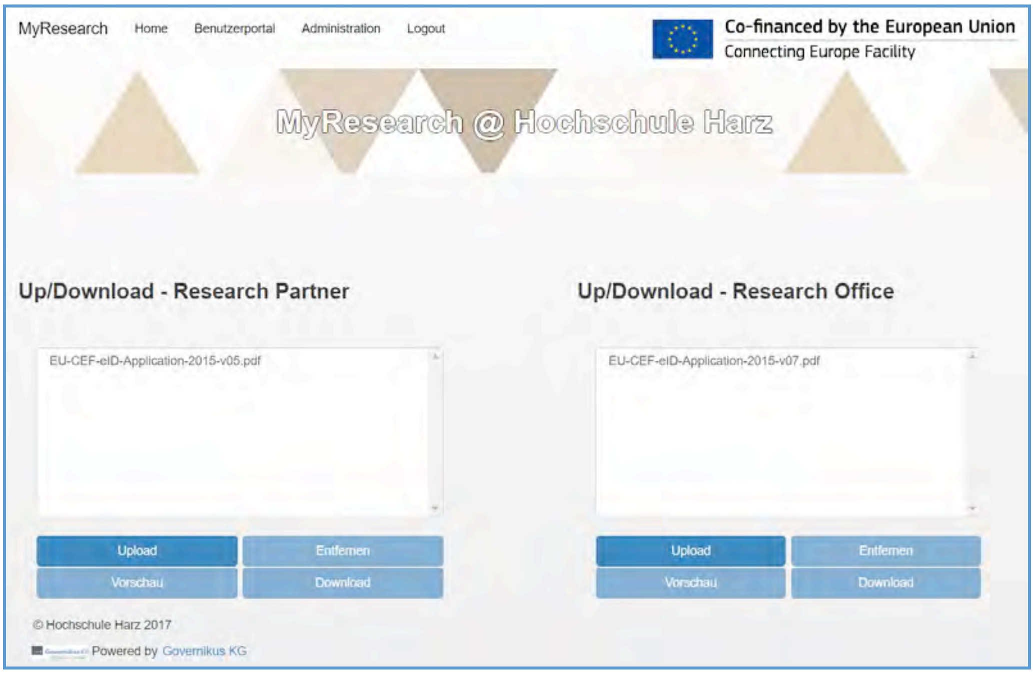

Figure 5: eID based R&D Admin. web site, for eIDAS extension (TREATS)

7. TRANSFER & Outlook

Some items of this work at university context has options for transfer to public administration, e.g. in the context of approval of professional qualifications and of electronic service access to public administrations [6], especially the upcoming legal validity of eIDAS regulation concerning eID in September 2018. Furthermore, in some contexts a fully digitalization with effectively securing of (university) documents may need some legal procedure adjustments nowadays. Not only because of the known threat potentials for the authenticity and integrity of paper documents, an according regulation of effectively secured digitalization of such documents security and egovernment standards acc. state of the art (QES, eSignature/eSeals, eIDAS) would be important in the future. In future, potential valuable combinations of cryptographic security mechanisms with media security approaches should be further researched to increase the overall security and privacy, especially for hybrid approaches (paper and digitally based documents). For example, in respect to data origin authenticity and/or data integrity the combination of approaches which modify the original data (called also active approaches) might be useful. This includes steganography and digital watermarking (as already discussed briefly in section 4). Questions about the additional security value needs to be discussed and appropriated algorithms selected or further enhanced, see as discussed in [17].

Further, media security approaches which passively investigate authenticity and integrity (called also passive approaches) might be valuable to increase the security of the involved processes. This include media forensics (posterior, without any prior information as known from digital forensics). This addresses doubts on the integrity or authenticity of involved documents as well as suspicious traces during document life cycle processing. Image manipulation detection techniques can support this by determining and locating originality and integrity infringements of the electronic documents or checking printed document versions. Media forensics approaches need to be selected and further enhanced for its application for important documents, see work for example in [19]. As the digitalization of industrial processes is an ongoing important topic, the securing of identity and configuration management at these sites could be accordingly supported.

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http://www.informatik.uni-halle.de/ti/mitarbeiter/wefel/

EUNIS 2017: Student-centricity and data openness in a CRM system for higher education

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Keywords
Student-centricity, data openness, CRM, partnership management, customer management, process development

1. SUMMARY / ABSTRACT

Higher education institutions battle with conflicting ICT demands: operational pressures drive the need for more detailed information repositories, while the nature of the public educational institute and its duties toward students drive for data openness. This case study describes the design and deployment of a CRM system for a HEI that has brought key customer data at the hands of its students. The system balances between closed data and open data, and centralised vs distributed administration.

Higher education institutions (HEI's) face new types of challenges in their education processes and in lowering economical situation (Cook 2017) as many other actors in present situation. There is a demand to be ecomically more effective and in Finland demand to regional development and having strong regional influence are rising higher among many demands. HEI's are in a need to become more publicly accountable and demonstrate added value. In a fast-moving socio-economic, political and technological environment (JISC 2013) HEI's are facing problems in data management, particularly relating to customer and partners hip data to cover the needs based on new growing demands.

While many HEI's have information repositories for stakeholders or business customers, these seldom cover the entirety of the instution's footprint. A HEI's impact results from the sum of its activities, whether with educational partners, business transactions, research programs, or stakeholder issues (Rigo et.al. 2016 p.56 and Lindh 2010 p.4). However, because of the different nature of these fields, it is very difficult to govern an over-arching outlook of the data.

As a result, a CRM is challenging to set up for managing partnerships and customers in a larger scale. The problems appear to exacerbate when a system implementation needs to integrate multiple platforms between separate functions in the organisation. There are study processes and business processes alongside which challenges the traditional uniform way of CRM use. Conventionally, CRM is used as a main data resource for business critical processes. Because of the inherent differences between educational institutions and businesses, a different approach may be appropriate. A CRM

project is more than an IT project in a HEI. Our observations suggest it can be more of a cultural change project.

This study describes a practical case that highlights the challenges and possibilities needed to find common processes and solutions for effective CRM use in a HEI. The paper and the project that it describes is part of a change process that has been evolving in the case organisation. Some of the theoretical underpinnings are described in a previous paper (Ylikoski & Kortelainen 2012).

This case study relies on empirical methods as well as earlier research on partnership management in general, in HEI's and particularly, in regional development in HEI's. We will raise questions such as "Who is going to be the primary user?", which are typically not on the critical path in conventional CRM implementations (Van Vugt & Knasys 2015 p.41).

The study is following A.D. de Groot's empirical cycle (Heitink 1999) using data from earlier CRM-projects in Laurea as well as some other studies concerning CRM implementations in a HEI. This supported with the series of workshops having teachers, students and other actors in Laurea to contribute for the project and the study inside it. When thinking that nearly half of the CRM implementations fail in provate sector (Larson 2013) it is no wonder that already in early phase the hypothesis was clear that we should find a new approach to get CRM implemented effectively – even four earlier projects had been failed trying to get CRM-system defined and implemented (Ylikoski et.al. 2015 – 2017). Data from earlier tryouts was valuable to this study and showed clearly that earlier we have had completely wrong approach to CRM in HEI. With knowing the earlier experience it was chosen to do definition of the system from completely new perspective of using CRM in HEI.

The case organisation, Laurea University of Applied Sciences in Finland, relies on a rather unique operational model termed Learning by Development. Most studies include real life projects with businesses and other organisations. In practice, Laurea handles several hundreds of real worklife projects all the time, and more than 90% of those are carried out by the students as part of their studies. (Ylikoski & Kortelainen 2012 and Ylikoski et.al. 2015 – 2017) Due to this approach, worklife partnerships are in the core of Laurea's strategy. As a consequence, it is imperative to be able to document, manage and utilise the partnership information in an effective way. Hence the need for a new type of CRM thinking.

A typical CRM is designed to support the needs of an organisation's employees. However, because of the unique nature in this case, we designed the system especially for the student's needs. While it is important that the staff use the system as well, the students of Laurea are on a critical path in terms of data entry, management, and review. In fact, partnership data responsibilities lie on the shoulders of students. In most cases, partner information is entered and managed by the students.

We are aware that it is far from typical to allow an educational institute's 8.000 students access to its core CRM. However, in terms of Laurea's approach and ethos, this is actually quite logical. It is based on a core belief of true cooperation with the student and a high regard for the student's work. There are practical issues as well. During last decade, Laurea has attempted to implement or build a shared CRM multiple times. These attempts have suffered from the typical employee-centricity where the main responsibility and burden has been on staff. The attempts have not been successful.

This paper describes a different approach; one that builds directly on student use and offers support for the core processes of a HEI (Noaman & Ahmed 2015 p.394): education, research, and regional development. It also reverses the transaction. In a traditional CRM, staff are required to enter their customers' data in the system for shared use. This faces substantial problems in a HEI, where partnerships are often tied to individual research interests and perceived as personal property. By reversing the logic, we are hoping to avoid this downfall and create positive benefits for the staff.

Needs for high quality partnership information management have been constantly growing during last years in Laurea, like in many higher education institutes (Ylikoski et.al. 2015 – 2017). As a part of developing the regional development activity, Laurea's management decided on acquisition and implementation of a suitable CRM to support partnership management. Because of the particular situation as described above, the system was branded as "PRM", Partnership Management System. It is intended to cover much more than "just" customers.

The system implementation took place in a time when data openness, shared knowledge and lean six sigma are current topics. These had a substantial impact on the implementation. Partner organisations are not allocated to managers as in many commercial implementations. Although the information on key persons is available, the system does not inherently limit access. This allows for a distributed ownership model where multiple persons can be in charge of a partner organisation. Some sensitive data areas are exceptions.

Students as CRM users has other benefits as well. It offers a great possibillity for students to learn to use and understand CRM in a real production environment. Moreover, basic use is relatively easy due to a user friendly portal, through which users can access the system. Full scale CRM is also available when needed for the needs of partnership information management and project management.

The best knowledge to produce and maintain the partner organisation's basic information is in the hands of the partner organisation itself. One key theme in the project relates to data openness and enabling partner's limited use of the system is on the roadmap, although not implemented in this phase.

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Automating lecture capture using Opencast

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1. ABSTRACT

Lecture recordings are being used more and more by universities. To be able to achieve a high coverage of recorded lectures this process needs to be automated. At the University of Münster this is being done by using Opencast in combination with fixed recording equipment in the lecture halls. The lectures are being recorded automatically and most of the video processing is automated as well. Although, not the whole work process is automated yet, there are ways to make this possible in the future by connecting a learning management system or a campus management system.

2. INTRODUCTION

The use of lecture recordings is more and more common. They are well received by students and are considered very useful among the students at the University of Münster (Dageförde, Marek, & Reischmann, 2016). The University of Münster is using Opencast to record lectures and in the following it is described why and how this has been implemented at the University of Münster. Section 3 covers the reasoning why one would want to record lectures and why it is desirable to automate this process. This is followed by section 4 in which some background information is provided about the lecture recording system used at the university of Münster and how it has been implemented. Section 5 then covers how the different parts of the lecture recording process have been automated followed by what still needs to be automated. Next, the sections 6 and 7 are about the usage of the lecture recordings and how the lecture recording service has been perceived by the students as stated in the evaluation. Lastly a short summary is given.

3. RELATED WORK

This section analyses usage scenarios, benefits and drawbacks identified from related work. The literature shows that the practice of recording lectures is becoming more common at universities. The way this has been implemented and is being used differs a lot. However, it is usually positively received by the students. Bennett & Glover (2008) reports that 91% of the surveyed students stated that lecture recordings assist their learning.

For the usage of lecture recordings there are multiple scenarios. The two main use cases are the reviewing of the lectures with the recordings for better understanding and the usage of the recordings to prepare for exams. Possible other scenarios could be to use lecture recordings to provide additional material to ambitious students (Montrieux, Vangestel, Raes, Matthys, & Schellens, 2015), or to flip the classroom and have the students watch the recordings at home and use the time with the students for exercises or questions from students (Makarem, 2015).

Zupancic and Horz (2002) identified three usage groups among their students. These are:(1) students who do not use the lecture recordings, (2) students who occasionally use the lecture recordings and (3) students who make intense use of the recordings (Zupancic & Horz, 2002). While intense users of the lecture recordings always watch the full recording, occasional users sometimes just watch parts of a recording (Tillmann, Bremer, & Krömker, 2012). Additionally, students are stating that they prefer to watch a video to prepare for a lecture over reading a text (Woodruff, Jensen, Loeffler, & Avery, 2014).

The observation that lecture recordings are not always fully watched is connected to the usage of the recordings by the students and how much attention they are spending on it. While lecture recordings are watched in full during exam preparation they are not always needed in full length, in some cases a short part or a summary can be enough (Van Zanten, Somogyi, & Curro, 2012). Advantages that are often cited by students are that lecture recordings allow them to determine their own learning speed (Tillmann, Niemeyer, & Krömker, 2014) and that they are able to review missed lectures (Rust & Krüger, 2011). Especially for students who are not able to attend many lectures the lecturer recordings are of value (Wieling & Hofman, 2010). For them the recordings make it easier to have a job while studying (Tillmann et al., 2012) or to take care of ones family (Rust & Krüger, 2011).

Being able to review difficult parts of a lecture is being perceived as helpful and leads to more students passing the course (López-Pérez, Pérez-López, & Rodríguez-Ariza, 2011; Montrieux et al., 2015; Zimmermann, Jokiaho, & May, 2011). Especially students, who otherwise would have failed, benefit from the lecture recordings (Zimmermann et al., 2011). In addition, a frequent use of the lecture recordings can lead to a positive change in course performance (Whitley-Grassi, 2017).

The possibility to watch lecture recordings influences attendance less than often assumed. According to Zimmermann et al. (2011) some students state that they use the lecture recordings as an alternative to attending the lectures, although the number of students who attended the lecture in this study did not decrease. Others like Tillmann et al. (2012) state that among occasional users of lecture recordings the attendance dropped by 12% and for intensive users by 20% while Leadbeater, Shuttleworth, Couperthwaite, & Nightingale (2013) reported a general decrease in attendance by ~15%.

As Nagai (2009) stated there are three parts to lecture recording, pre-processing, recording and post-processing. The pre-processing usually consists of getting in contact with the lecturers, getting consent to record and schedule the recordings to be recorded either manually or by a computer. The recording phase usually consists of setting up the recording equipment and actually recording the lecture while post-processing usually consists of uploading, editing, and publishing the recording. Of these parts the most labour intensive part is the recording (Nagai, 2009). In the following, the recording part is described in more detail.

The traditional way of making a recording is to show up somewhere with a camera and simply point the camera at whatever needs to be recorded. Although, in the context of lecture recording more is required then just a video of the lecturer. Additionally, it is relevant to also record whatever is shown on a beamer, in most cases the presentation, along with the video and audio of the lecturer (Stolzenberg & Pforte, 2007). There are two approaches to also getting the relevant information shown on the beamer. The first approach is to record one video signal with a wide range that covers the lecturer as well as the content shown on the beamer. In the second approach only the lecturer is filmed and the beamer is recorded separately, which leads to a higher quality recording.

If the choice is made to record the beamer signal separately there are two ways to achieve this. One can record the input document with a symbolic recorder application or one can record the output document as it is shown on the beamer with a screen recorder (Ziewer, 2007). Recording the input document refers to running the recording software on the same computer as the content to be recorded, for example by using a plugin to Microsoft PowerPoint and getting the slide text as well as the slide change events directly from Microsoft PowerPoint. This has the advantage that it provides additional metadata about the recording that can be accessed while playing the recording. However, it has the disadvantages that it is limited to presentation software that is supported by the recording software and that it is prone to human error (Ziewer, 2007).

Recording the output document can be done by external devices, such as a video grabber, which records everything that is being send from the presentation computer to the beamer. This has the advantages that it is not tied to the recording software and is not prone to human error as it works independently of the presenters computer. The lecturer can also use other programs to show information to the students. However, this causes the drawback that extra information, such as text on the slides, needs to be extracted while processing the recording (Ziewer, 2007).

With the recording of the presentation separated from the recording made by the camera it is possible to focus on recording the presenter and the audio. Nevertheless, the recording of the presenter is of less importance than the recording of the presentation and the audio. However, it is still needed as it makes the recording more engaging for the students and helps to keep concentrated while watching the recording (Kizilcec, Papadopoulos, & Sritanyaratana, 2014). Therefore, it is desirable to keep the presenter in focus. This can be accomplished during the recording, by having a person standing behind a camera in a lecture or automatically by using PTZ cameras in combination with tracking software like LectureSight (Wulff & Fecke, 2012) or by using cameras with included digital tracking, as for example provided with some Axis cameras (Axis Communications AB, 2017). During post-processing it can also be accomplished by analysing the movements within a recorded video and rendering a tracking version of it, an example of this kind of software is Track4K (University of Cape Town, 2016).

It is debatable whether the manual recording approach or the automatic recording approach result in recordings of better quality, which is also depending upon the usage scenarios of these recordings. The consideration of manual or automatic recording comes down to the following three arguments: (1) how likely are human errors, (2) what are the costs and (3) how well does it scale.

On the one hand, the manual recording approach is quite prone to human errors as there are many possible error sources. These could cause an error every time a lecture is recorded. Such sources are, for instance, setting up the camera correctly, configuring the presentation software and recording software to interact correctly, or having to plug in the video grabber correctly. To guarantee the success of a recording, a member of the recording team has to transport the recording equipment to the lecture hall, set up the recording equipment, record the lecture and afterwards pack the recording equipment again. Considering the amount of work that needs to be done manually a 90 minutes lecture recording can easily amount to up to 2.5 hours of work. This might be feasible when the number of recordings per week is relatively low and while there are only a few recordings at the same time. Once there are multiple recordings in parallel in different locations the personnel required to cope and the resutling costs would increase a lot (Nagai, 2009), which most universities just cannot afford (Mertens & Rolf, 2003). Thus, the manual recording approach is not scalable.

On the other hand, the automatic recording approach is not prone to errors as the whole process of recording takes place automatically using recording devices equipped with video grabbers and cameras that track the presenter. Once the initial setup is done no manual interaction is needed. This requires more work to get started but leads to less errors in the long run. Since no personnel has to be present for the recording, the number of people working on lecture recording is lower then in the manual recording approach. This also means that adding another lecture hall does not automatically has to lead to an increase in personnel. This, therefore, means lower costs and a better ability to scale. This is described in more detail in section 5.

4. TECHNICAL SETUP

The University of Münster started lecture recording in the summer of 2014, although only on a small scale. Based on the positive feedback from the students the General Students' Committee requested a centrally funded project aimed at lecture recording in June 2015 (Allgemeiner Studierendenausschuss der Universität Münster, 2015). This was approved in July 2015 and the lecture recording project started in November 2015. The aim of this project is to have up to 20 lecture halls equipped with lecture recording technology until the end of 2017. Considering the aim of the project and the size of the University of Münster a few requirements for the lecture capture system were drawn up. These included the ability to:

- record automatically based on a schedule,
- publish recordings automatically to a predefined destination,
- record more than 2 sources at the same time in high definition,
- play back more than 2 sources at the same time,
- host the server infrastructure on university servers,
- scale the server infrastructure as needed,
- define the video processing workflow,
- integrate learning management systems.

Based on these requirements the lecture capture solutions Opencast (Apereo Foundation, 2016), Kaltura (Kaltura Inc., 2016), Panopto (Panopto, 2017) and MediaSite (Sonic Foundry Inc., 2017) were compared. The main reasons for choosing Opencast were that it can be hosted on university servers and can easily be scaled. Furthermore, it allows us to work with a wide range of capture agents.

Opencast was initiated by 13 institutions from North America and Europe to develop a web based open source system aimed at automating lecture recording that would meet common requirements (Ketterl, Schulte, & Hochman, 2010). Opencast runs on Linux which enabled us to choose a fast and lightweight container runtime, Docker. This allows to put the focus on the applications and not the machines. Additionally, the running behaviour can be easily reproduced which makes testing easier.

Concerning the capture agents, there are quite a few capture agents on the market, as shown in a comparison by Burriel & Dechter (2016). However, none of the capture agents on the market offer the needed flexibility in configuration and remote maintenance that we need in a diverse and wide spread teaching environment as we have at the University of Münster. Therefore, we chose to make custom capture agents, which can be adapted to each specific lecture hall. The capture agents are running on Linux as well and use pyCA (Kiesow, 2017) as the capture agent software. Furthermore, our custom capture agents have baseboard management controllers which allows for complete remote maintenance.

Principles for the successful implementation of lecture recordings in higher education have been published by Ollermann, Rolf, Greweling, & Klaßen (2017). Upon designing our lecture recording system we were not aware of these principles. However, we were in contact with one of the authors and also use Opencast. This resulted in our lecture recording system being similar and following some of the described principles. Especially the described principles of efficiency, flexibility, usability, compatibility and high coverage have been applied while some work is still needed concerning the principles of integration, autonomy and reliability.

5. AUTOMATION

Once the lecture capture system is set up one can start automating the recording process. As previously stated there are three phases to the lecture recording process, (1) pre-processing, (2) recording and (3) post-processing (Nagai, 2009). In the pre-processing phase the first step is to contact the lecturers and get their consent for the recordings, which is done manually. Once the lecturers give their consent the integration of the course in learning management system and the series in Opencast can be set up, this is done manually as well.

Following the efficiency principle of Ollermann et al. (2017) the automation process starts with the scheduling of the events to be recorded. At the beginning of the semester the lectures that are to be recorded are scheduled in the lecture capture system. This means that the lecture capture system, in this case Opencast, manages which capture agent has to record which signal at which time. This recording schedule is transferred from Opencast to the capture agents.

The recording phase starts with the capture agent starting to record according to the schedule provided by Opencast. Our capture agents can record four signals at the same time, depending on the wishes of the lecturer. These are: the audio and beamer signal provided by the media-control-devices installed in the lecture hall as well as two camera streams provided by an Axis network camera, one being the full view of the lecture hall and the other being a digital autotracking video (Axis Communications AB, 2017). During the recording the lecturer can hold the lecture as he or she is used to without having to change anything because of the recording. This can be achieved by recording the video signal that goes to the beamer and the audio signal of the microphone that the lecturer uses anyway, as described in the flexibility principle (Ollermann et al., 2017).

The post-processing phase starts with the capture agent automatically uploading the recording to the Opencast server. The Opencast server then starts processing the recording according to a previously defined routine, a so called workflow. After the initial processing is done the recording can be edited and trimmed. Afterwards the processing continues on the Opencast server, again according to a previously defined workflow. After processing the recording is automatically published to the previously configured course in the learning management system, which increases the usability as the interface of the learning management system is already know to the users, according to the usability principle (Ollermann et al., 2017). If it is requested by the lecturer a control step can be added before the recording is published to the learning management system. Using the learning management system the students then can access the Opencast player, a HTML5 player which delivers MPEG4/H.264 encoded video to the user, as stated in the compatibility principle (Ollermann et al., 2017).

So at the moment, the only operations that need to be executed manually are (1) notifying the lecturers and getting consent to record from the lecturers, (2) the scheduling of the recordings, (3) the integration into the learning management system, which only needs to be done once per course in the pre-processing phase, and (4) the editing of the recordings which needs to be done for every recording in the post-processing phase. The most labour intensive part of the lecture recording process, the recording, is already fully automated.

This however, is still quite a lot of work that needs to be done manually if one takes into account that the aim of this project is to record up to 20 lecture halls till the end of 2017, and possibly more after that. Most of the work that still needs to be done to further automate our work processes concerns the principles of integration, autonomy and reliability (Ollermann et al., 2017). At the moment, entering the metadata about the recordings and the scheduling is being done manually, which could be done automatically as described by Ollermann et al. (2017) using a plugin in the learning management system or by connecting a campus management system to Opencast as it has been done by the University of Manchester (Schiebeck, 2017).

Concerning the connection to the learning management system to achieve higher autonomy, as described in the autonomy principle (Ollermann et al., 2017), some work needs to be done as well. While there is a plugin for Stud.IP which gives as much control as feasible to the lecturer, such a plugin for Moodle, which is used as the central LMS in Münster, does not exist yet. Although, it is under development.

As for the reliability principle (Ollermann et al., 2017), we do not have backup recording systems yet, although we do monitor our devices and only had two failed recordings in the winter term 2016/17. One recording failed because of connectivity issues and the second recording failed because the audio signal was not provided by the media-control-device in the lecture hall. We seek to minimize the risk of human error because in our case the metadata still needs to be entered manually, which again could be solved by either a close integration with the learning management system or a campus management system, or both.

Lastly, as described in the high coverage principle (Ollermann et al., 2017), we try to achieve a high coverage so as to reach as many students as possible. At the time of writing we equipped 13 lecture halls with recording systems and more are in planning. However, all lecturers whose classes take place in the equipped lecture halls are still being contacted manually and asked if they want to participate. This limits the possible coverage to the classes of lectures who want to be recorded. Another approach to this is to move from an opt-in approach to an opt-out approach, like it is being done by the University of Manchester (Phillipson, 2017), where all lectures are being recorded by default. There is an increasing move towards an opt-out approach according to Rios-Amaya, Secker, & Morrison (2016).

6. ANALYTICS

Once the recordings are made, included in the LMS and made available for the students the first question that often comes up is whether the students are actually watching the recordings. In Opencast 2.x some data is already being collected via a user tracking service in the player, although it only tracks the number of hits per recording. This however, is already enough to gain some insight into the usage of the recordings as Ebbert (2017) demonstrates. Lectures were given from the 17th of October 2016 until the 10th of February 2017 with the exams taking place shortly after the last lecture and the semester ending on the 31st of March 2017. The usage over the first few month of the semester is comparable and as soon as it is time for the exams the usage increases as expected, as shown in figure 1. The end of the lecture time, the 10th of February 2017 is marked in figure 1 with a red line. Starting after the holidays around new years eve the number of hits on the provided recordings increases till the end of the lecture time, then drops and increases again in the end of February. The statistics for single lecture series show similar usage patterns as the overall usage of all recordings.

Although the information gained using the user tracking endpoint in Opencast 2.x can already be quite interesting, it I still quite limited. One way to solve this is by integrating Piwik into the

Opencast player, which has been implemented by Rolf (2017). This makes it possible to track how often a video has been played and paused, at which quality and playback rate it has been watched and whether the users made use of the zoom function or not. This functionality will be included in Opencast 3.0 and should provide administrators with additional information as to how the students interact with the provided recordings. However, it does not yet provide information about which parts of the video have been watched and how many times those have been watched, which could be used to identify potentially difficult parts of the lecture recordings. This could possibly be done using the Media Analytics plugin for Piwik provided by Innocraft Ltd. (2017).

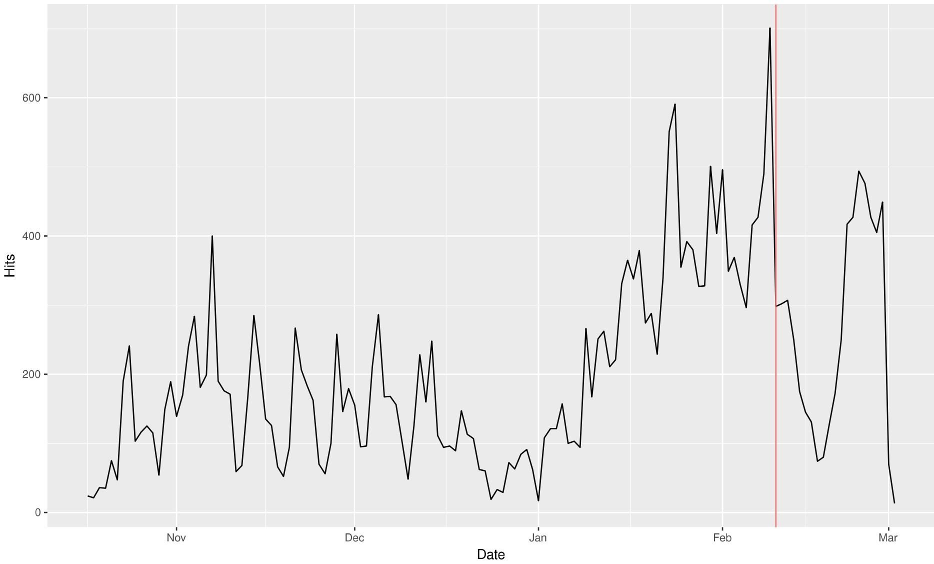

Figure 1: *Hits on lecture recordings over the winter term 2016/17, the red line representing the last lecture given (Ebbert, 2017)*

7. EVALUATION

At the end of the semester, the lecture recording service was evaluated among the students who had access to it. The data collection for the evaluation took place by means of a survey which the students had access to via the learning management system. The survey was open from the 29th of January 2017 till the 21st of February 2017.

The results of this evaluation were especially of interest in terms of the reported usage as well as the subjective quality of the recordings. Most of the students stated to have watched nearly every recording, sometimes even multiple times. If they watched the recording they usually watched the whole recording. Reasons for doing so were that the recorded lectures covered difficult topics and the students were reviewing the lectures in order to better understand what was said. For this purpose they usually watched the full recording.

About half of the students stated that they attended less lectures because they could expect to have access to a recording afterwards. The reasons for doing so according to the students were mainly so that they could learn at their own pace but also because they had to work or were sick. Additionally, the students stated that the recordings support them in their learning progress, especially before the exams.

The part of the lecture recording of which the quality was of the most importance to the students was the sound quality, followed by the quality of the slides and lastly the quality of the video of the lecturer. All in all the students were satisfied with the provided service and wish that the lecture recording service is going to be extended to cover more lecture halls and lectures given (Ebbert, Marek, & Paulus, 2017).

8. SUMMARY

To summarize, providing lecture recordings is well received and sometimes even expected by students. Lecture recordings can assist students in their learning as it gives students more flexibility to study at their own pace, to review missed lectures or difficult parts (Ebbert et al., 2017) and to make it easier for students to have a job while studying (Tillmann et al., 2012). The attendance drops by 12% to 20% according to (Tillmann et al., 2012) although the number of students passing their courses can go up (López-Pérez et al., 2011; Montrieux et al., 2015; Zimmermann et al., 2011).

There a a few lecture recording solutions on the market and at the University of Münster we chose to use Opencast as we want to automate as much of the lecture recording process as possible. This is being done by using fixed recording equipment in the lecture halls and scheduled recordings. This way, the recordings can be scheduled in advance and the recording takes place automatically. After the recording the video files are automatically uploaded and processed. Cutting the recording takes place manually and afterwards the recordings are also automatically published to the LMS.

What still needs to be done manually is getting consent from the lecturers, setting up the LMS integration per course and scheduling the recordings as well as cutting every recording. Although, there are ways in which this can also be automated. For example by connecting a LMS plugin or a campus management system that provides the metadata and schedule for the recordings. The cutting of the recordings can possible be outsourced to the lecturers or their assistants.

The students used the recordings as expected and stated in the evaluation that they were satisfied with the provided service. Most of the students stated to have watched entire recordings and the recordings were also used as expected, to review difficult parts or whole lectures and in preparation for the exams.

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10. AUTHORS' BIOGRAPHIES

Daniel Ebbert is working in the lecture recording team at the University of Münster since December 2015 while finishing his Masters' degree in Technical Communication at the University of Twente. In July 2015 he obtained a Bachelor degree from the Saxion University of Applied Sciences in Information Services and Management. From August 2012 till June 2013 and from September 2014 till January 2015 he also worked as a Audio Video Technician for lecture recordings at the same University of Applied Sciences. In the time frame between those jobs he was doing a web development internship in Xiamen, China as part of his Bachelor program. He wrote his Bachelor thesis about information retrieval by foreign tourists in Lithuania and is currently writing his Master thesis on appropriation in learning management systems.

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Sharing videos in FUAS

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Keywords
Study process, enterprise architecture, university co-operation, video platform

1. SUMMARY

FUAS (Federation of Universities of Applied Sciences) is a strategic alliance formed by Häme, Lahti and Laurea Universities of Applied Sciences. This paper describes how FUAS has found the way on how to share videos to each other.

2. BACKGROUND

Häme, Lahti and Laurea Universities of Applied Sciences are independent higher education institutions. They have a common FUAS-vision 2020 - "FUAS enables the member institutions to offer the students high quality education and the broadest range of study opportunities throughout the academic year". The vision is paired with FUAS-strategy 2015-2020 "The Virtual Campus increases the studies offered digitally, regardless of time and place, and it provides students with tailored study paths.". FUAS has also introduced a so-called FUAS Campus. FUAS campus is a virtual campus (eCampus) which compiles online studies, learning platforms and a shared video platform.

When planning the shared video platform, flipped classroom method was an important principle, guiding us through the process. Before the shared platform, we used YouTube for sharing the videos. However, we had some problems with it: copyright and ownership challenges, integration to other systems (for example Learning Management System, LMS). The most critical issue was that there were no proper possibilities to share the videos within FUAS. So we had a need for better solution. We started our project by clarifying the enterprise architecture. It was important for us that both staff members and students should be allowed to upload videos into the system.

3. SOLUTION

3.1. The Concept of the solution

Figure 1 shows the concept of our solution. We have a shared media repository which contains all the material. Only administrators are using that. Then each organization has its own video portals and connections for learning management systems (LMS).

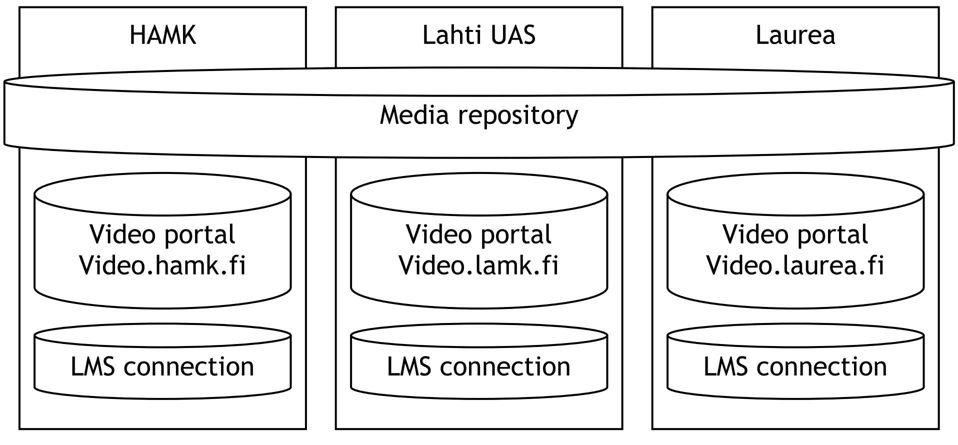

Figure 1: The Concept of the FUAS video platform.

The technology we base our solution on is Kaltura and the system is offered by NORDUnet. The configuration is done without code customization.

3.2. The implementation process

If we compare our solution to single organization's video platform, trust is a key element in our case. We need to trust to each other.

Also consensus is critical. For example, we had to negotiate:

- Metadata structure we are using. Without this it would not be possible to share the videos for other organizations. Also all setups within the repository needed to be agreed.
- Licenses we are using for the material. We use same licensing for all the material. We recommend to use the CC-licenses but we also have all rights reserved –license.
- Terms and conditions for end users. This is important because now we know that all users have agreed same terms and conditions. The terms and conditions need to be agreed before uploading videos.

We need to be careful when changing media repository system parameters. We need a change management policy for the system.

This means that implementation time is longer and it takes more work to agree on everything. The most difficult thing was to find the way on how the three videoportals and one repository can be configured so that sharing the videos in FUAS is possible.

4. SOME STATISTICS

We started piloting the system in May 2016 and full production was in September 2016. In May 2017 the total amount of medias in the system was about 3900. We have about 52 000 plays and the videos have been played for about 4 700 hours. We are really satisfied on these figures.

5. FUTURE DEVELOPMENT

We are still missing some guidelines. For example, we don't have a decision when we should or could delete videos from our platform. If the owner of the video is not working for us anymore or if the owner (student) has graduated and the video does not have CC-license, how long should we store it?

We are also waiting for new versions of the platform. Especially better native apps for Android and iOS would be useful.

We also have a group of pedagogical and IT experts collecting the data. They will recommend practices and procedures to video-assisted learning in FUAS Campus.

6. AUTHORS' BIOGRAPHIES

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EUNIS 2017: Audiovisual environments between digitalization and declining budgets

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Keywords
Audiovisual (“AV”), digitalization, flexible, multifunctional, future ready, cost effective

1. ABSTRACT

Audiovisuals in classroom has been the same for years, but now digitalization and cut of costs are setting up new standards and challenges for upgrading classrooms and providing support to digital era. Helpdesk and procurement are battling with declining budgets and human resources. This paper presents Metropolia’s current plan for the future audiovisuals as well as some data behind decisions. The paper also presents the challenges that we are currently facing and how we are planning to cope with them. Do your users constantly struggle with beamers, because previous user has “fixed the problem” before them? Is there a permanent demand for support person to be present on events “just in case something goes wrong”?

2. Introduction

Even the economy is now getting better, we tend to have more money for investments, rather than for the operating costs. This happens especially in the field of the education and the technology. The fundamentals of the government funding for the Universities have significantly changed. These combined we end up in a situation, where we have the hardware, but we don’t have the person to support it.

When we talk about digitalization and audiovisual systems, we must dig a bit deeper than the hardware-side. Digitalization is not about changing the overhead projector into a document camera. For us, digitalization is a combination of automation and combining information from many sources.

In the recent ECAR 2016 research by EDUCAUSE, we found out these requests from Finnish students about teaching; “Share all the materials through internet, preferably in advance”, “Record lectures”, “Visualize. Use games, real-life data and simulations to enlighten and illustrate”,” Keep the data in one place. Do not disperse the methods”. [1] These requests do not have much to do with the audiovisual technology itself, but with the whole environment where the studying is happening. In this environment, the audiovisual systems are a key layer, and therefore it must work perfectly to provide service.

To meet these expectations in classrooms, we must find technical solutions that are easy to use and automated as far as possible to prevent user related technical problems. Classrooms must share the same user experience in terms of standardized connectivity and adaptability. The technology should be easy to maintain and provide support – remotely for flexible support. The environment has to allow easy installation of devices. We have been collecting data and we have made several piloting, or proof of concepts, builds to provide data and find the best way to improve our classrooms.

3. THE PAST

Metropolia is a legacy of two organizations, which means that our audiovisual systems had dozens of different kinds of implementations. If we had put two normal classrooms side by side, they could have had totally different AV equipment’s. As every time, there was a tender, the outcome was also different. Every auditorium had a different kind of user interface and the amount of hardware was something incomprehensible.

The situation was quite unbearable because of the amount of support needed. Around year 2010 our former ICT-procurer Joni Junnila and ICT-manager Mikko Mäkelä began hardware standardization. This meant that we started to implement classrooms and auditoriums with coherent audiovisual devices, standard coupling and unified user interfaces.

4. THE PRESENT – How AV-technology promotes digitalization

To prepare for BYOD and digitalization we have started process to upgrade all classrooms from VGA-connector and WXGA-resolution into HDMI-connection and WUXGA-resolution with fully automated signal switchers. To maintain standards and unified environments we have process management software to document all classrooms and communicate with the suppliers.

We also have unified the user interface in all auditoriums and brought service called "Self-service auditorium", where all user can stream whole auditorium by themselves. This service was an answer for the constant need of local support and/or a camera crew to stream.

Since AV is not the tool itself, but an enabler and facilitator, we don't believe that the answer for easy collaboration lies in hardware. Work, picture and audio already transmits to everybody's PC through software and network. Cloud services has made their debut in the two past years and really taught us that they are the tool to enable collaboration regardless of time or place. This observation strengthens the idea about a cake, where AV is one layer, and collaboration is one layer on top of it.

5. The future

Future classrooms will be multifunctional and versatile, we already see this trend rising when we look at the teaching methods or even the classroom furniture's. So, could the AV be versatile too? For our future campuses, we have added a possibility to change the position of teacher's desktop let's say once a year and the place and projection direction of the beamer.

Biggest change will follow in the management. All audiovisual devices will be remotely administrated and controlled through the server. This way we can reduce the amount of time and resources used to giving support on premises. Server is also capable of providing helpdesk tickets about maintenance, lamp hours and many more. Also, we will get detailed usage reports to plan for future implementations and procurements. Technical solutions and details mentioned in this paper will be covered in my presentation.

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7. AUTHORS' BIOGRAPHIES

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How to start with learning analytics? Infrastructure and support.

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Keywords
Learning analytics, infrastructure, hands-on experience, experiment, online study activities, xAPI, learning records store, visualization.

1. ABSTRACT

Better insight into the teaching process and targeted feedback to students, ultimately resulting in improved education: that is the idea behind learning analytics. Learning analytics makes it possible to follow students' digital footsteps. These footsteps can be recorded and analysed, leading to the creation of comprehensive data collections. With this data, it is possible to make predictions about, for example, the quality of the teaching materials used, how teachers and students interact with the material, how the digital learning and working environment is used, etc. Learning analytics offers a great many possibilities, but how can an institution use it successfully? This is the reason why SURFnet started the Learning Analytics Experiment for Dutch institutes for higher education to gain experience with learning analytics. With this experiment, SURFnet demonstrates the possibilities of learning analytics in education. In this paper we present the set-up of the Learning Analytics experiment, the learning analytics architecture and infrastructure used for this experiment as well as the preliminary results and further work.

2. INTRODUCTION

Learning analytics is often viewed as a complicated process by educational institutions. Frequently asked questions include: How do I use learning analytics? How can I use the data indirectly provided by students during online learning in order to provide targeted feedback? This raises other questions: Is learning analytics secure? What about the students' privacy?

In 2016 SURFnet started the Learning Analytics Experiment for Dutch institutes for higher education to gain hands-on experience with the above-mentioned aspects of learning analytics. With this experiment, SURFnet offers the institutes a learning analytics infrastructure which demonstrates the possibilities of learning analytics and shows how learning analytics can link to educational processes and provide insight into student activities. At this moment, a second round of experiments is running, including improvements based on the first round.

SURFnet is the Dutch NREN (National research and education network) representing all Dutch institutes for higher education and research. SURFnet's mission is to boost the quality of education and research through the support, innovation, development and operation of an advanced, reliable and interconnected ICT infrastructure, enabling the potential of ICT to be harnessed to its full extent. One of the innovation topics, which SURFnet is addressing, is Learning Analytics. This is done in a multi-year innovation program in which all institutes for higher education can participate. Main goal of the learning analytics project is to support institutions to gain insights in the way learning analytics can contribute information about the teaching process and targeted feedback to students, ultimately resulting in improved education.

In this paper we present the set-up of the Learning Analytics experiment, the learning analytics architecture and infrastructure used for this experiment as well as the preliminary results and further work.

3. SET-UP OF THE LEARNING ANALYTICS EXPERIMENT

Learning analytics offers the possibility of supporting students in their learning on the basis of educational data. It can provide teachers with real-time information about the quality of the learning material and the course curriculum. Learning analytics can also provide insight into online study behaviour both for students and teachers. In addition, it offers teachers and educational developers a new and practical source of information alongside their own observations and evaluations.

With the experiment, SURFnet aims to create a safe and secure environment for experimentation, by taking care of the infrastructure (including learning records store and visualisations), the process, privacy issues and hands-on support.

By carrying out this experiment, educational institutions can answer the following questions: Is learning analytics really so complicated? How does learning analytics fit into an educational infrastructure? How do you collect data? How do you visualise data? How do you obtain permission from students?

Furthermore, the process of collecting data becomes more transparent. The experiment will show which questions are used to obtain the data and how this data is analysed and visualised. In this way, institutions don’t have to reinvent the wheel by themselves.

3.1. Approach

Within the experiment, SURFnet provides insight into student activities. It measures which online activities students actually perform. Educause (2007) defines five steps of analytics:

1) Capture: the process of extracting the data from the source and storage in a common location (mostly a learning records store).

2) Report: examine the information, and identify trends, patterns, and exceptions in the data and then visualize it.

3) Predict: to make predictions based on the reports.

4) Act: to act and make interventions based on the information

5) Refine: improvement of the analytics process and start again with 1).

SURFnets experiment focusses on the first two steps. Our focus is not on making predictions with data, but on making improvements to education. We measure and display the data, and educational institutions participating in the experiment can decide for themselves whether they will make any changes to aspects of education based on the displayed data.

The process of collection and visualization of the data consists of four steps:

Step 1: Formulate the questions to be answered:

It is important to first consider which data needs to be collected. In other words: Which questions can we answer with the data? Teachers and educational developers can determine these questions, potentially in collaboration with management.

SURFnet has formulated five questions for this experiment while working in collaboration with educational institutions:

- Which materials are frequently used?
- When does the student carry out learning activities?
- Has the student submitted the assignments and when were they submitted?
- How often does the student take interim tests during the course?
- Does the student monitor their own progress?

Step 2: Create Xapi recipe and collect the data in the LRS

xAPI recipes will be created for the educational questions listed above. This is the second step.

To be able to collect data, the xAPI recipes need to be linked to the applications used by students. When they are linked, data can be collected, analysed and organised. Data collection is performed in the Learning Record Store.

Step 3: Complete the dataset and analyse the data

After collecting the data in the Learning Record Store, the organisation and analysis of the data is carried out in the Learning Analytics Processor. Data is tailored for specific visualizations and data sets are placed in the context of a course, with start- and endtime and number of students. Also all relevant objects from the xAPI recipes are accounted for.

Step 4: Visualise the results

The data report will be shown on a webpage where the teacher and student can view and evaluate the visualisation for one of the educational questions. The teacher can then decide whether to give feedback to the students based on the visualisations. The process of providing feedback is not part of this experiment.

3.2. Learning analytics architecture & infrastructure

In order to facilitate the above described learning analytics process, SURFnet has developed a learning analytics architecture and built a learning analytics infrastructure. This infrastructure shows how the different layers within a learning analytics system – input, data storage, business and presentation – are connected.

The technical architecture (see figure below) of the infrastructure can be divided into four layers:

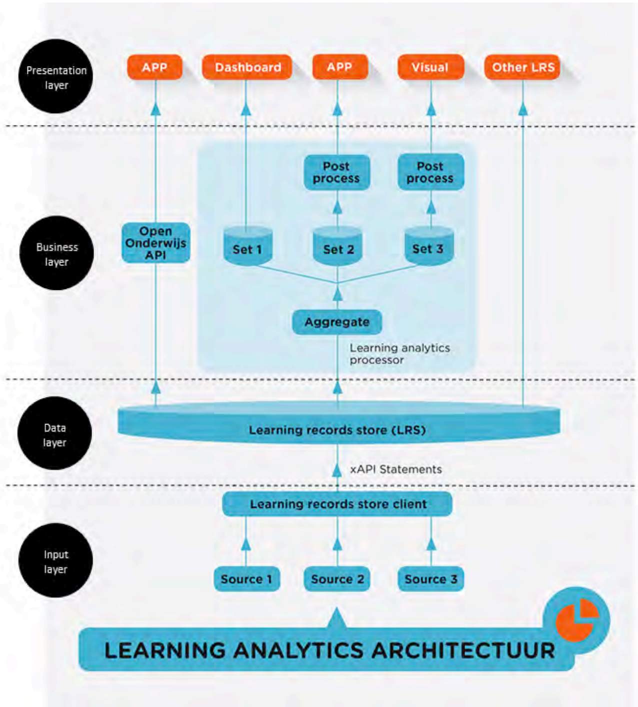

Figure 1: Technical architecture, with the four layers

1. **The presentation layer, which provides the visualisation.** The visualisations are visual presentations of the results of the Learning Analytics Experiment, which are intended to provide teachers and students insights into study behaviour. These visualisations are displayed on a dashboard.

2. **The business layer, which provides the functionality for the experiment.** This is the Learning Analytics Processor, which aggregates, organises, analyses and customises data from the Learning Record Store for different users in the presentation layer.

3. **The data layer - the centre of the architecture.** The most important component is the Learning Record Store, which is for storing student activities carried out in the various online learning environments used by students.

4. **The input layer** To which various sources (environments) are connected that provide the LRS with the activities.

This architecture brings two advantages. First, the components are based on open standards and therefore vendor independent. Second, the architecture is separate from the different kinds of digital learning environments and sources that are used within the institutions, so it is possible to collect data from various sources.

Regarding the capture process, the input layer ensures that data is collected in the LRS. Student activities originate from different sources and reach the LRS in a uniform manner through the LRS client developed by SURFnet.

The functionalities that are used in this process:

1. Tracking the student. Since student activities are distributed across various sources, it is important to clearly identify the student at each source.

2. It should be easy for the teacher to collect the student activities. This is achieved by removing the complexity of the xAPI from the source and monitoring the activities with simple javascript code via the LRS client.

3. The javascript code at the source is translated to xAPI statements used as input for the LRS. These xAPI statements record the type of student activity according to a defined xAPI recipe.

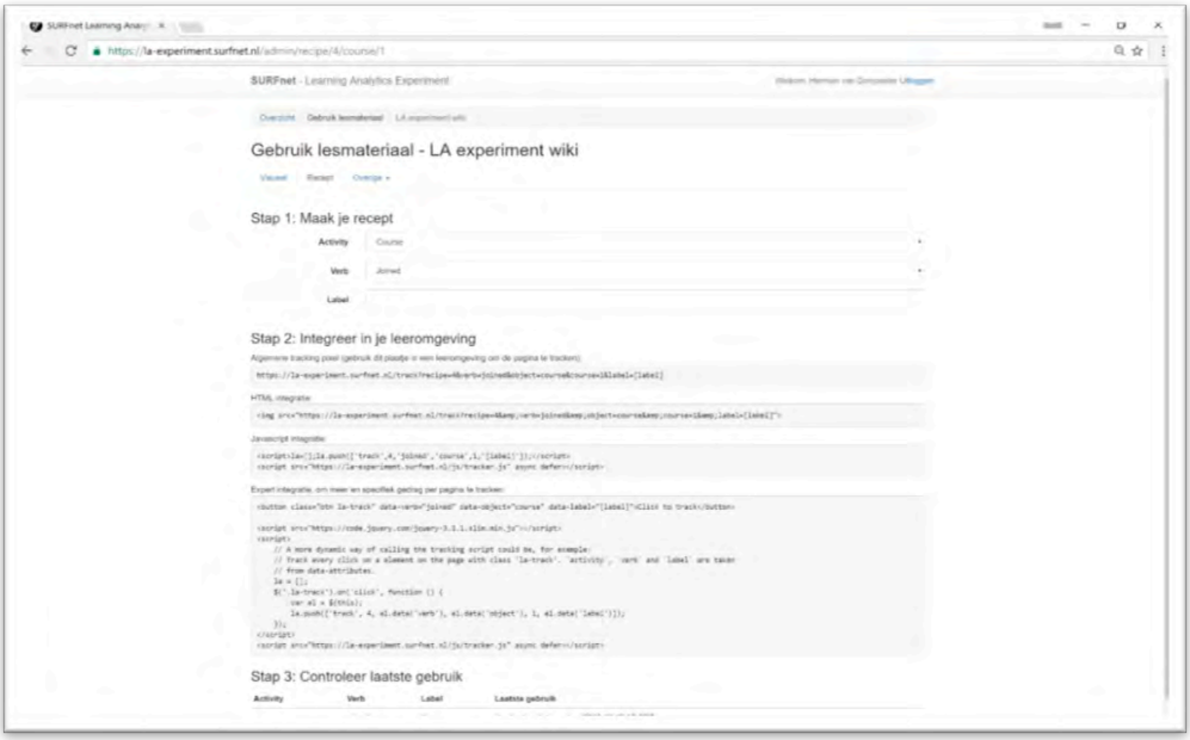

Figure 3: Creating xAPI recipes

The reporting process of generating datasets, post process data and visualizing is taken care of in the business and presentation layer:

Collecting data results in a huge amount of student activities in the LRS. In the Learning Analytics Processor, statements from a particular student are aggregated in a dataset, which then serves as input for the visualisation of the data. Different datasets are prepared for different visualisations. Datasets are stored in a uniform format, which allows post processing to occur in order to prepare data for visualisation. Simple visualisations require zero or very little post processing. For other visualisations, it may be necessary to interpret the data and organise it correctly prior to visualising it.
The Learning Analytics Experiment focuses on visualisations of the questions asked by teachers. Visualisations can be easily interpreted by teachers, so they can determine any steps that need to be taken.

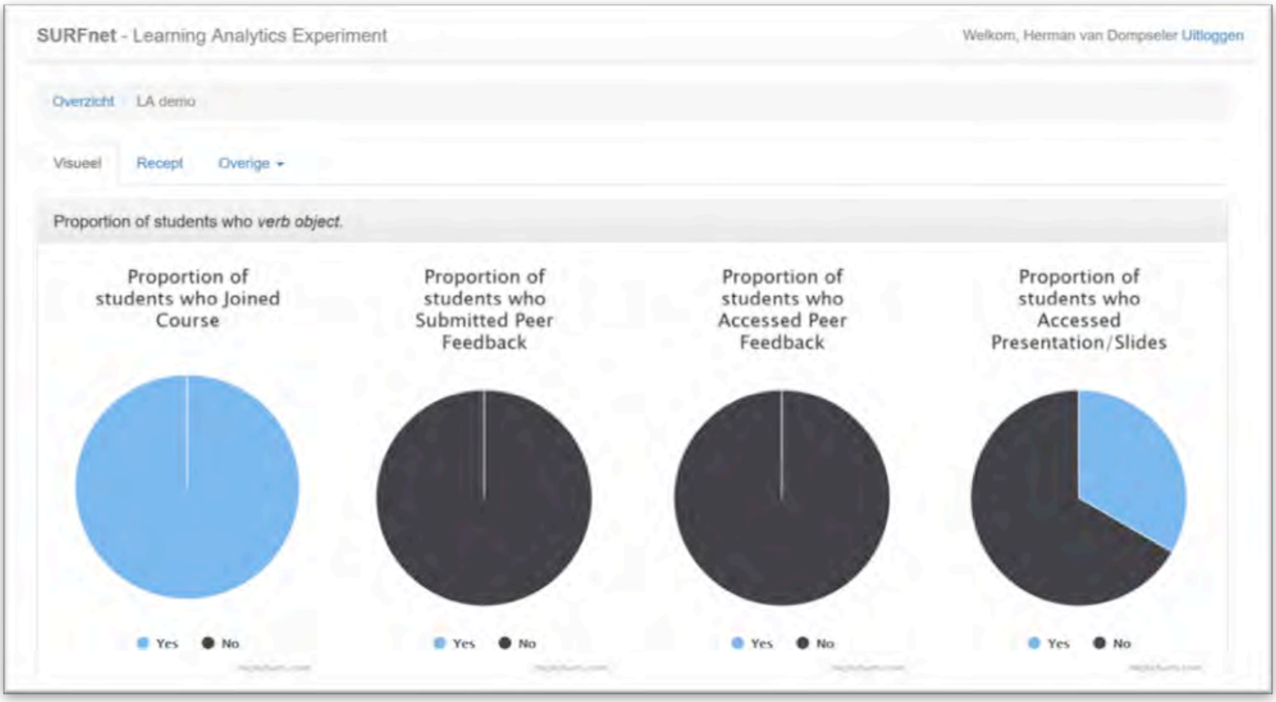

Figure 4: Example of visualisation

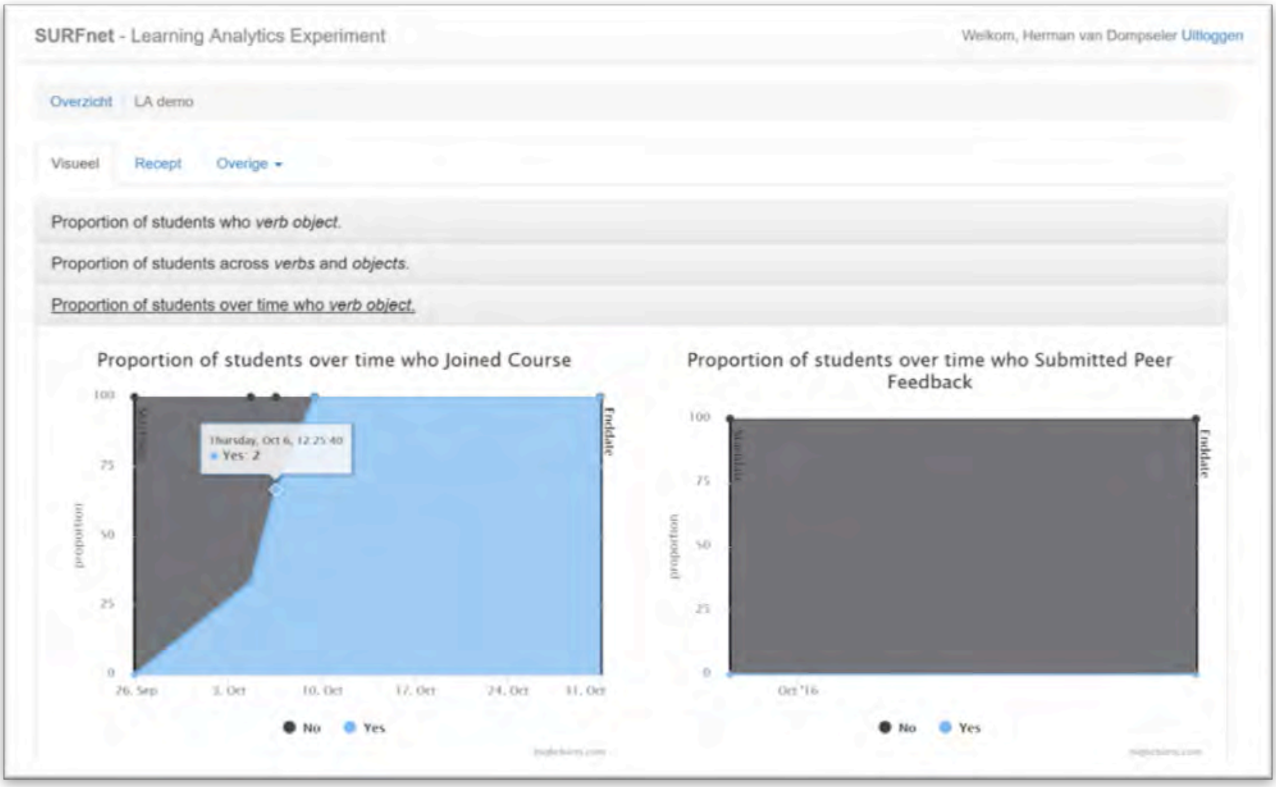

Figure 5: Example of visualization

3.3. Minimalizing privacy issues, hands-on support and documentation

3.4. Generic consent form

In the experiment, SURFnet aims to take care of as much constraints as possible for the institutions. This resulted in a generic consent form for the students participating in the experiment. Although this form has to be approved by the institution's privacy officer, most of the time the form is 100% adopted without any changes. Also because of the fact that SURFnet made clear rules and regulations of the use of the students' data.

3.5. Hands-on support

During the process, SURFnet offers hands-on support to teachers an IT staff. In practice, this means an intake with teachers and staff of an institution who are interested in participating in the learning analytics experiment. After the institution has decided which course will take part in the experiment, a meeting is planned with the teacher(s) involved. In this meeting, all ins and outs of the construction and implementation of the xAPI recipes are explained and brought into practice. Then, the course and thus the collection and visualization starts. We have contact on a regular basis and survey the experience with the experiment on both the teacher as well as the students. After the course, there is an evaluation and all lessons learned are collected. Lessons learned input for further development of the infrastructure and the process, and they are made available for other instiutions who aim to start with learning analytics.

3.6. Documentation

All documentation, like a user manual, interpretation and explanation of the visualisations and the xAPI recipes, is is available on a wiki. The source code of the experiment is available via Github (https://github.com/SURFnet/learning-analytics).

4. PRELIMINARY RESULTS

Despite the fact that the first round of experiments is finished two months ago and the second round just started, there are some preliminary results that can be shared in this paper.

Since the launch of the learning analytics experiment, 3 institutes of higher education participated in the experiment and used the learning infrastructure in daily educational practice. In the last couple of months over 500 students and 5 teachers worked with the learning analytics infrastructure. With this experiment, students and teachers are able to follow the learning process, near real-time. What's also interesting is that all the participating institutes use various learning management systems, such as Blackboard, N@tschool & Mentorix.

We learned that it was easy for teachers to get started with learning analytics. The infrastructure is running in the SURFnet Cloud, so there is no "burden" with IT implementations within the institution. Creation of the xAPI recipes was fairly easy for teachers by using our developed tool. It takes time to implement the recipes in the learning management system, but all teachers found it worth the effort.

Teachers think the learning analytics experiment is a useful tool to monitor students activities. At this moment, it is experienced as a promising project. In the future, it can be the basis of an effective educational intervention because 1) it provides real-time data so the intervention can be on time, 2) intervention can be done on personal level and 3) the goal is to identify students who are at risk of dropping out and to give targeted feedback.

The value of learning analytics for students can be found in the fact that students find it useful to have a better understanding of their study process.

All to all, what we have learned till now is, as long as you connect the use of learning analytics with the educational process, teachers and students are having a lot of advantage, by looking at the students' data on study activities. It seems that insight in actual learning activities provides valuable information which is not available in regular usage statistics.

For 2017 it is the ambition of SURFnet together with the Dutch institutes for higher education, to improve the learning analytics infrastructure and to offer more institutes, teachers and students the possibility to work with the infrastructure. We work together on creating evidence, guidelines and tools for effective use of learning analytics.

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6. AUTHORS' BIOGRAPHIES

Marieke de Wit is community manager at SURFnet. She is responsible for the Learning Analytics and Digital learning environment projects, in which she brings IT in education professionals together in networks and collaborative projects in order to support institutions with their developments on IT in education. The last 7 years she was project manager of several innovation projects at SURFnet. Before SURFnet, Marieke worked at the Dutch ministry of economic affairs as policy advisor digital government. She holds masters degrees in business sciences (2002) and public information management (2007). https://www.linkedin.com/in/mvandevecht/

Herman van Dompseler is a freelance software architect and software designer for internet applications. He is most interested in the innovation cycle of a software product, working from ideas to product to data according to the lean startup methodology. For SURFnet he worked on several innovation projects the last years, with the topics: Learning Analytics, Digital Learning Environments, Groups Management and Streaming Video Services.

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EUNIS 2017: QUANTIFIED STUDENT

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Keywords
Quantified student; learning analytics; study success;study improvement;good practice;real life demos;privacy;really smart mobile

1. SUMMARY / ABSTRACT

It is a simple idea, really.

Learning is all about feedback. Runners, for example, use apps like the RunKeeper. Research shows that apps like that enhance engagement and results. And people think it is fun. The essence being that the behavior of the runner is tracked and communicated back to the runner in a dashboard.

We, at Fontys University, wondered if you can reach the same positive effect if you had a dashboard for study behavior. For students. And what should you measure, track and communicate? We wondered if we could translate the Quantified Self Movement into a Quantified Student.

So, together with students, professors and companies we started designing & building Quantified Student Apps. Apps that were measuring all kinds of study behavior related data. Things like Time On Campus, Time Online, Sleep, Exercise, Galvanic Skin Response, Study Results and so on. We developed tools and prototyped the apps with groups of student. At the same time we created a Big Data Lake and did a lot of privacy research.

The Big Difference between the Quantified Student Program and Learning Analytics is that we only present the data to the student. It is his/her data! It is his/her decision to act on it or not. The Quantified Student Apps are designed as a Big Mother never as a Big Brother.

The project has just started. But we already designed, created and learned a lot.

1. We designed and built for groups of prototypes for study behavior apps:
    a. Apps that measure sleep & exercise and compare it to study results, like MyRhytm;
    b. Apps that measure study hours and compare it to study results, like Nomi;
    c. Apps that measure group behavior and signal problems, like Groupmotion;
    d. Apps that measure on campus time and compare it with peers, like workhorse;
2. We researched student fysics to see if we could find his personal Cup-A-Soup-Moment (meaning, can we find the moment (by looking at his/her biometrics) when concentration levels dip?);
3. We created a Big Data lake with student data and open data and are looking for correlation and causality there. We already found some interesting patterns.

In doing so we learned a lot. We learned it is often hard to acquire the right data. It is hard to create an app or a solution that is presenting the data in the right way and presents it in a form of actionable information. We learned that health trackers are still very inprecise. We learned about (and solved some) challenges surrounding privacy.

This year (2017) we will scale the most promising prototype, measure the effects, start a new research project and continu working on our data lake. Things will be interesting, and we will blog about it on www.quantifiedstudent.nl.

2. PAPER

2.1. Introduction

Suppose I am a runner and I would set myself a simple goal. In a half year I would like to run the half marathon (21 km) in one hour and 45 minutes. So every other day I put on my running shoes and start to run. I do not use tools like a Google Maps or a timer. I just run like I feel is best. The last few weeks for the half marathon I intensify my schedule and I run every day. Then, the race starts. I feel I am ready. Two hours and 3 minutes later I finish. Well, I think, let's try again in 6 months and this time I have to train harder.

Sounds a bit absurd, right? Why didn't I use a Runkeeper-kind-of-app? A smart schedule and constant feedback about my running would have helped me greatly to a achieve my goal. And it probably would have been more fun too.

Still, a lot of our students are studying like the runner-without-an-app. They think they study hard, but do they really? They think they make the right decisions for study success, but do they? They have almost no data/information about their study behavior. **Wouldn't it be interesting to provide them with the data and find out if it helps them be a better student?**

We see it everywhere in the consumer market. People are starting to measure themselves with devices like Fitbits and Jawbone, or apps or smart tools (like Body Analyzing Scales). Inspired by this Quantified Self Movement we decided to start a program in December 2015 to try an find some answers. We called the program **The Quantified Student**.

2.2. Phase One. Design Guidelines & Goals

We started the program by drafting some design guidelines and goals for the first year. We thought it really important to create a strict framework in which this program would take shape. The guidelines were:

1. All work done will be **part of our education**. Groups of students will work on assignment, students will write their masterthesis on this subjects. Professors will be fully involved;
2. We will **NOT start a scientific discussion** about the pros and cons of this idea. We will start doing things from the start. We will create prototypes, calibrate students, collect and analyse data and so on;
3. We will be **very aware of privacy - issues** and make sure all our efforts are within the boundaries of privacy law and our moral code;
4. We will be **very transparent** and blog about all our findings on www.quantifiedstudent.nl;
5. **Failure is a option.** This project is all about learning so we created a safe environment in which failure was celebrated as much as success.

Our goal was to start 3-5 projects in 2016 that should all be very concrete. All projects were to result in hands on, showable prototypes. In 2017 our goal is to start 5 new projects and take one of the projects of 2016 and try to scale it to the University level.

2.3. Phase Two. Run Projects

Starting januari 2016 we decided to run three totally different projects. We will describe the projects and the results in more detail on the next few pages.

Project 1. ProtoTyping Studybehavior Apps

Can you design and create an app that helps students become better students? That was the central question we asked 120 students divided in groups of 10. They worked on answers for 4 months and we will highlight some results and also talk about some challenges we faced during this project.

Prototype number One. The MyRhytm App.

A few group of students set out to create an app that finds and shows patterns into a students sleeping habits and his/her study results. One of the groups created the MyRhytm App. An app combining reaction time with sleeping patterns. The working premise was a study that showed a correlation between reaction time and study results. The idea was simple. A few times a day the app was challenging you to do a simple reaction test (you had to pinpoint your girlfriend in a group of photos) and the results were compared with your sleeping patterns. If bad sleeping patterns were negatively impacting your reaction time you got suggestions for improvement. By monitoring the improvement slowly a 'MyRhytm' per student was established.

Of course the practical use of such an app is low but building it learned us about privacy challenges and the difficulty of tapping in to the FitBit data.

Prototype Number Two. Nomi.

Other group of students tried to create an App that was focusing on plain, old studytime.One App was called Nomi and focused on high school students. In the Netherlands a lot of high schools have all their assignments and homework registered in a central student information system called Magister. The app tapped into Magister so the student could see what had to be done. Everytime the student started a task he clicked on the Nomi App that consequently blocked the phone for 20 minutes (Pommodore-style). This way the student gained insight in the hours he/she spent for studying for an exam compared to his/her fellow students. So, in the past you might thought you studied hard. Now with Nomi you know for sure.

The students that created the App started a StartUp company and are currently in discussion with Magister and some high schools to build a commercial version of the software.

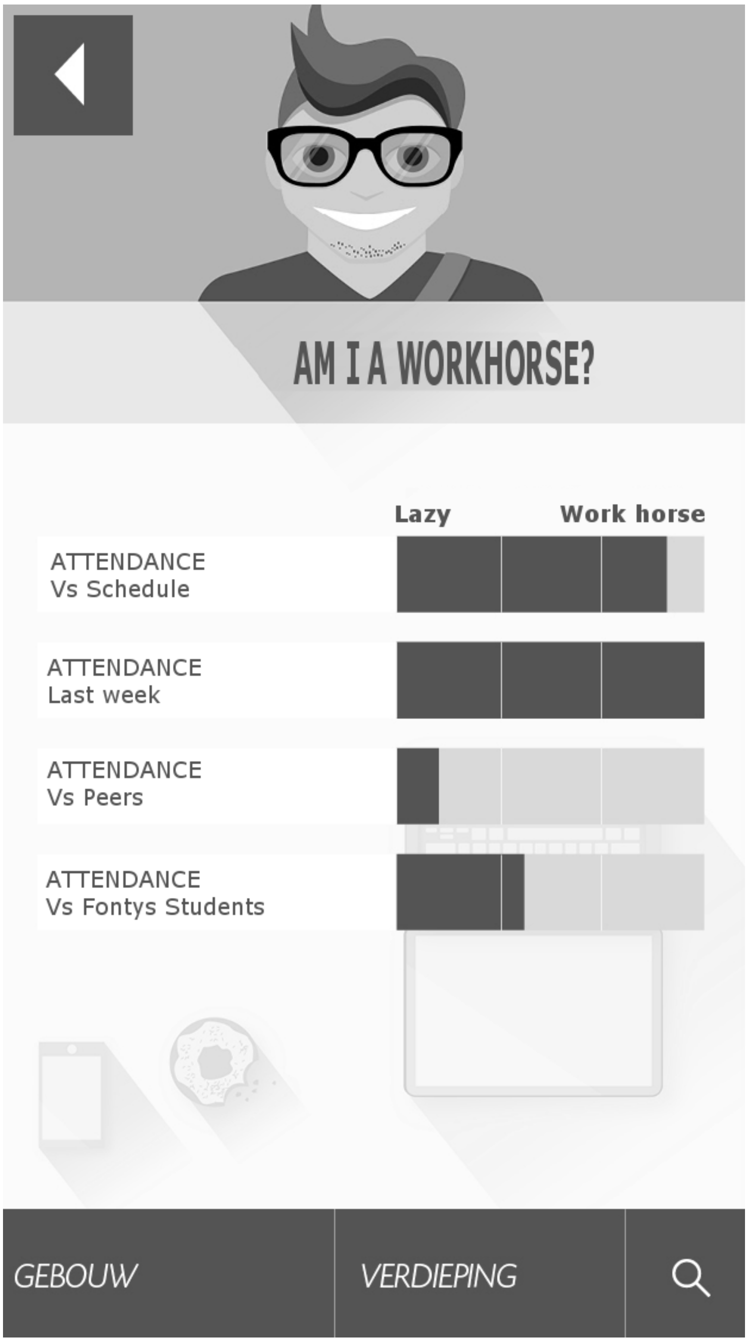
Prototype Number Three. GroupMotion

Students that work in groups a lot hate two things: people that do not really contribute and snitches. There is a paradox. So these students built an app called GroupMotion that quantifies the movement and emotional state of the group. By using GPS data and asking group members about their well being they were able to pinpoint problem areas like a student not moving with the group or a student feeling uncomfortable. These problem areas were communicated back to the student so he/she could make some necessary adjustments.

The software worked like a charm although the moral, privacy and ethical consequences of an app like GroupMotion are complex. As a prototype it truly was a thought provoking piece of work.

Prototype Number Four. The WorkHorse

Finally we had some groups of students that concentrated on translating the WIFI – data into insight in study behavior. Fontys University has a very large network (over 2500 Access Points and 30k concurrent users) and almost everyone instantly connects when they walk into our buildings. Still, if you ask someone how many hours are students are spending on campus, nobody knows. Of course they can check the schedule, but that is only paper. So students started working with this WIFI – data and build the build the WorkHorse App.



This app showed the attendance of a student and compared it to its schedule, its peers and all students of Fontys University. Playfully it showed if you are putting in more or less hours than average. Are you a workhorse or not? The idea is that you receive some suggestions that can help you change your behavior and you can also share this data with your counselor (if you like!).

Project 2. Your Personal Cup A Soup Moment

We had two students working on their master thesis in 2016. One student of psychology and one student ICT. Together they designed tests for groups students and while they were doing the tests they were measuring the biometrics of the students. The idea was to try and find a causality or correlation between the results of the test and the biometrics. This way it would be possible to measure when concentration levels dip and students better take a break (in the Netherlands we call this a cup-a-soup break). Wouldn't it be great if you were wearing a system that could warn you to stop studying and take a mini-break?

Early results showed some promise, but also showed that the measuring equipment is not precise enough yet. In 2017 we will try again with better tools!

Project 3. Swimming in a Data Lake

At Fontys University we have a Minor specializing in Data Science. In this minor we adopted a Quantified Student project. A lot of data is collected and anonimized in a large data lake. Think WIFI – data, e-learning statistics, data from health trackers, open data from our buildings (like temperature, lux, and so on), study results and all kind of open data (such as weather, public transportation, trending on social, daylight, etc…).

The data students are looking voor correlation or causality in the Data Lake. One of the first things they found was the relation between daylight and attendance of students. Some schedules were improved accordingly.

2.4 Fase Three: 2017

In 2017 we will do (at least) three projects in the Quantified Student Program. **First** we will scale the WorkHorse Prototype App. We already made some arrangements with a company that helps us organising the WIFI data & we aim to add the functionality to the common Fontys University App. After the summer every student at Fontys University will be able to see the number of hours spent on campus compared to his/her schedule and peers. And we will act within the privacy laws.

Secondly we will start a new reseacrh project to try and find biometric indicators for concentration levels. This time we will use better measuring – instruments. We already have selected some wearables that are not available on the consumer market yet.

Third, we will keep adding data to our data lake and start new project with students. One of the extra things we will do is challenge our students to create visualisations of the activity on campus. For example, how many students are on campus now? How are they divided by type of education? Men or women? Do men start earlier, make longer days? Or women? And so on. These visualisations will become an integral part of our culture.

3. AUTHORS’ BIOGRAPHIES

Rens van der Vorst is Head of IT Innovation at Fontys University. His aim is to enhance education by using IT. Rens also works as a technophilosopher. In this role he helps education to prepare students for functioning in a society that is determined by (rapdly changing) technologie. Before his current role Rens was CIO and Head of Operations at Fontys and before that he worked as a program-manager-for-hire.

Rens has a major in Political Science and is very active in the Dutch Educational Community. He leads Advisory boards on HE-connecting infrastructures, has a seat in the Advisory Board of Cisco, was one of the fouding fathers behind an IAAS solution for all Dutch HE and he is also responsible for the success of the Dutch Benchmarking Initiative.

Rens is a gifted presenter who did some TedxTalks about different subjects and is very active on all kinds of conference and other meetings. He mainly speaks about the future of thecnology and the impact on us humans and society. Rens is also writer for CIO.nl and runs a platform called technophilosophy.com.

Rens is 46 y/o, has a wife and two kids and like all Dutch people he is an incredible gifted soccer player, or so he thinks.

The logic of numbers - How numeric data reveals the processes of learning and teaching

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Keywords
Learning Analytics, E-Learning-Strategy, Moodle, Educational Data Mining

1. ABSTRACT

In our presentation we would like to share our views and reflections on Learning Analytics in higher education. We therefore start by examining the future integration of Learning Analytics at the University of Duisburg-Essen, specifically in the context of the recently introduced E-Learning strategy. We proceed by attempting to define the terminology and describe the understanding and aim of Learning Analytics. Following, we present first opportunities to put Learning Analytics into action, especially in the environment of the learning management system moodle, which will also include authentic evaluations of moodle courses. Finally, we will present first attempts for the future work with, the realization and the incorporation of Learning Analytics at the University and beyond.

2. EXTENDED ABSTRACT

2.1. Background and strategic directon

The University of Duisburg-Essen (UDE) is one of the ten largest universities in Germany and offers about 42,000 students a broad academic spectrum with an international orientation and a bride expertise in implementation of E-Learning formats. E-Learning has turned into an everyday feature of teaching and learning and has to prove its worth in helping universities to cope with the growing number of students, their increasing diversity and requirements. To promote E-learning at the UDE the university management decided to establish a university-wide E-learning strategy in 2014. The aim is to incorporate E-Learning across all departments. This includes the aspiration to permanently improve courses of study and adjust them flexibly. The new strategy 2.0 is newly revised with new objectives and goals und current challenges in studying and teaching. Some of these are the development of E-Learning competences as well as the evaluation of how digital media technologies are used within this framework. Due to digitalization, more and more aspects of learning processes take place online and could therefore be accessed by using analytical means to understand such. The UDE is still at an early stage of first attempts of using Learning Analytics.

In this paper the described method will rely on research predominantly in moodle, as it has been defined as the strategic learning platform at the UDE and has been in regularly use throughout all departments. The data we collected in moodle are intended to improve courses of studies and teaching as well as individual feedbacks for students and teaching staff. Students get the opportunity to relate their own achievements with those of reference groups and to reflect on their own learning development. In order to foster learner autonomy, the UDE will promote the scientific research on Learning Analytics.

2.2. Definition of Learning Analytics

Learning Analytics and respectively the approach behind it has no general definition. You find definitions like „Learning analytics is the use of intelligent data, learner-produced data, and analysis models to discover information and social connections, and to predict and advise on learning“ (Siemens, 2010) and „Learning analytics is the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs“ (LAK11, 2010). The main focus of Learning Analytics is the understanding as well as the optimization of learning as a whole, including the specific learning context and its participants. To achieve this goal the relevant data of the learning environment are used with the help of intelligent methods. Big Data, Online Learning and political efforts to increase educational performance on a national and international level can therefore be understood as driving forces of Learning Analytics. Furthermore, one can identify different movements in the aforementioned areas (Educational Data Mining, Learning Analytics und Academic Analytics). It should be noted, however, that those areas show partial commonalities in their realization (Ferguson, 2012). The successful implementation of Learning Analytics calls for an interdisciplinary merging of various experts, because of the fact that different perspectives and layers have to be considered in order to meet the complex and multilayered requirements in this context (Ifenthaler & Schumacher, 2016).

The UDE understands Learning Analytics and the potential that is connected with it, as a chance to permanently improve the conditions of teaching and learning and to respond sensibly to the individual needs of its students. It can be viewed as one among several means to continually improve the quality of service and to increase the likelyhood of individual success in the students’ respective courses of studies. To achieve those goals in the future, it is intended to use the implementation of adaptive learning, user data of various E-Learning tools with the help of advanced methods of data analysis to utilize those accordingly.

2.3. Fist approaches on the integration of Learning Analytics

Offering Learning Analytics as a service within a conventional university, as opposed to an Open University, with heterogeneous faculties mainly concerned with face-to-face study programmes, requires to adapt Learning Analytics to heterogeneous kinds of online and offline learning. Often models of technology enhanced learning draw on a too narrow and specific understanding of learning. As an example therefore, the Community of Inquiry (CoI) approach conceptualizes learning as an inquiry process (Garrison & Arbaugh 2007; Garrison, Anderson & Archer 1999). Nevertheless, there are learning situations within the different scopes of science and teaching in which technology enhanced learning basically supports the distribution of content while collaboration and construction happens outside digital learning environments – offline. Therefore, introducing Learning Analytics needs a model of learning compatible with different situations of learning. The 3C model of digital learning offers a wider and more open understanding of digital learning. It states three dimensions of digitally supported learning environments (Kerres, de Witt 2003):

- Content: distribution of documents, videos etc.
- Communication: interacting and discussing
- Construction: self-directed or social knowledge construction

Following this model, the current approach of implementing Learning Analytics at the UDE aims at visualizing activities and content according to these dimensions in order to offer an instrument for reflecting the didactical profile of teachers and students.

2.4. Outlook

In order to achieve the aforementioned goals of permanent improvement of conditions of teaching and learning and the consideration of the students’ individual needs, the UDE initializes an autonomous work group for Learning Analytics. An interdisciplinary team, consisting of representitives of different faculties as well as central institutions accellerate an evidence-based, hands-on and sustainable realization of Learning Analytics. Furthermore, the initialization of cooporations with other insitutions of higher education in Northrhine Westphalia is intended to accellerate the implementation of Learning Analytics even further on a regional level.

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Tobias Hölterhof, Dr. Phil., is a postdoctoral researcher at the LearningLab of the Universtiy of Duisburg-Essen since 2013, technical section leader of the Lab's online master study programs and currently a visiting professor at the Heidelberg University of Education. He studied philosophy, information- and media science at the Heinrich-Heine-University Düsseldorf and finished his doctorate in philosophy. His current research deals with designing and analysing digital learning environments and social learning as well as philosophical issues of online education and learning.

A Virtual Environment and Infrastructure to ensure future readiness of Data Centers

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Keywords
ICT infrastructure, Virtual Environment, Personal Learning Environment, innovation management

1. ABSTRACT

The ongoing digitalization leads to a need of continuous change of ICT (Information and Communication Technology) in all university domains and therefore affects all stakeholders in this arena. More and more ICT components, systems and tools occur and have to be integrated into the existing processes and infrastructure of the institutions. These tasks include the transfer of resources and information across multiple ICT systems. By using so-called virtual environments for domains of research, education, learning and work, the performance of daily tasks can be aided. Based on a user requirement analysis different short- and long-term objectives were identified and are tackled now in the context of a federal research project. In order to be prepared for the ongoing digitalization, new systems have to be provided. Both, a service-oriented infrastructure and a related web-based virtual learning environment constitute the platform Campus.UP and creates the necessary basis to be ready for future challenges. The current focus lies on e-portfolio work, hence we will present a related focus group evaluation. The results indicate a tremendous need to extend the possibilities of sharing resources across system boundaries, in order to enable a comfortable participation of external cooperating parties and to clarify the focus of each connected system. The introduction of such an infrastructure implies far-reaching changes for traditional data centers. Therefore, the challenges and risks of faculty conducting innovation projects for the ICT organization are taken as a starting point to stimulate a discussion, how data centers can utilize projects to be ready for the future needs. We are confident that Campus.UP will provide the basis for ensuring the persistent transfer of innovation to the ICT organization and thus will contribute to tackle the future challenges of digitalization.

2. Virtual Environments for different user needs

Nowadays, the ICT infrastructure of universities is scattered with respect to organizational and technical aspects. While ICT changes rapidly and new technologies, design paradigms and systems evolve continuously, especially for university data centers it is hard to keep pace. On the one hand, they have to ensure the maintenance of legacy systems and thus constantly have to revise and conceptually redesign the historically grown infrastructure and systems. On the other hand, they have to recognize valuable trends and developments, which glimpse on the horizon (Johnson et al., 2016), and connect them with the aims of simplifying the daily business.

Aggravatingly, the digitalization proceeds in various university domains (e.g. education, research and administration) and affects all stakeholders involved (e.g. students, academic staff, scientists, researchers and non-academic staff). This poses a tremendous challenge for data centers to deal with the different needs and requirements and to best to cover all conceivable use cases. As a result, more and more infrastructure and systems appear and need to be integrated seamlessly into the existing business processes and have to be combined with the existing ICT landscape (Becker 2011). This in turn requires the conception and implementation of new service interfaces and sometimes the adaption or even the profound revision of the existing underlying infrastructure and systems.

While technology plays a crucial part in our daily life, ICT becomes also an enabler of previously inconceivable academic and research scenarios. Out of research projects completely new requirements arise, which do not have much in common with the traditional tasks of data centers (e.g. operation, maintenance and ensure availability). However, in this context data centers mission is to respond as quickly as possible to the changing conditions and to provide an appropriate infrastructure and solutions (e.g. research data management, digital humanities). A basic requirement is a working infrastructure, but neither researcher, academic staff student nor employees do get much value out of infrastructure in itself. This aggravates the situation of historically grown data centers, especially when developments in this direction did not take place in the past. As a result, the dilemma between having to innovate but also having to operate even more is an obvious one.

While more platforms, services and tools appear, especially for the various stakeholders it becomes challenging to keep track of the different systems. Although each group of stakeholders has individual needs, they all share the common fate of having to deal with ICT services and platforms that differ from one another in terms of of user guidance. Due to a limited interoperability, there are only few opportunities to share resources, artifacts and information between system boundaries. The daily usage of ICT systems for all stakeholders therefore turns into complex endeavor. In order to tackle these problems and to ensure the best possible support for everyday activities of university stakeholders, diverse virtual environments (VEs) arose over the last few years.

However, the field of VEs is very heterogeneous and stretches from dedicated platforms for learning and teaching to research or workplace learning. Especially in the field of technology-enhanced-learning, the term “Personal” is stressed in order to accentuate the focus on the individual person’s actions and the customized environment. Therefore, the terms Personal Learning Environment (PLE) or the Personal Research Environments (PRE) are used. If further web 2.0 applications, tools, content repositories and data sources get integrated within these environments, and the users are additionally able to manage these applications themselves, the environment is also referred to as a Learning Stack or an educational cloud (Johnson et al., 2016). To establish those VEs for personal and institutional contexts different approaches are used (Kiy & Lucke, 2016). They reach from a variety of web-based approaches (e.g. link lists, adapted social software and mashups) to desktop and mobile approaches (e.g. desktop widgets, browser extensions and mobile applications).

The majority of these VEs were developed as a part of large European research projects (Kiy & Lucke, 2016). As a result, these VEs lack in real connections to the basic ICT infrastructure of their universities (systems and operation, or rather: maintenance). Consequently, these environments do not constitute an ecosystem around students or lecturers by integrating central ICT services from the university. Due to the missing connection to data centers during research, these VEs were never fully operational, because neither the maintenance and operation nor the further development of such systems had been considered during the projects’ run-times. The data centers on the other hand often did not try to draw any kind of benefit from these innovative developments for their daily work or just did not take any notice of the projects.

This article presents an ICT ecosystem that combines research and operations aspects at core of the matter. A service-oriented infrastructure is presented, addressing the various demands of university stakeholders on different levels. Even though the work is theoretically based in the field of PLEs, it nevertheless extends the aspects to a broader audience and focuses on personalized learning, teaching, research and working. First, the needs of the stakeholders are summarized. Afterwards, the challenges are presented that have to be tackled in order to establish a new ICT infrastructure within a historical grown data center. Because the current focus lies on e-portfolio work, the according use cases and an evaluation of the e-portfolio focus group are described in the following. The article closes with a discussion, how both innovative research and classic operation were combined in this project, and how classic data centers have to change in order to compete with the progressing digitalization in all university domains.

3. Rethinking academic practice and needs

Caused by the ongoing digitalization several aspects of our daily work and life are changing and affects university domains in various ways, ranges and speeds. Especially, university data centers and ICT organizations have to realign continuously to be able to meet current and future needs.

In order to get a good impression of user’s insights and to generate a meaningful overview of user’s current requirements and wishes, a user requirement analysis based on user stories was conducted across all status groups of the university until the end of 2016. Out of the over 200 different user stories, both short-term and long-term needs for the ICT infrastructure were identified, from which subsequently single steps of actions were derived:

- provide systems and technologies to enable new learning, teaching and research scenarios
- simplify the access and the discoverability of university tools, information and services
- reuse and combine services and functions across different software systems
- ease the transferability of information, resources and artefacts between system boundaries
- increase the autonomy of the users, thus they can achieve tasks with little support

From a technical point of view, the following short- and long-term objectives were identified:

- provide a spectrum of self-services to users (e.g. students, teachers, staff, researchers) to create an ecosystem according to their specific needs (e. g. software as a service by creating user-driven instances of wikis and blogs)
- aggregate isolated tasks from single systems in overarching processes, to improve the user experience, perceptual use and the productivity of students, staff and researchers
- provide an infrastructure with documented APIs which simplifies further developments, works as an service abstraction layer and allows the integration and reuse of external or federated services and tools
- offer a starting point for all services and tools within the university in a single environment
- support the individual creation of virtual learning and research scenarios and environments
- initiate a transformative process and a paradigm shift to everything as a service

While some of the objectives can be achieved with small efforts, others entail a lengthy process, affecting existing infrastructure along with changes of the established practices and attitudes. In the following, the status quo and the primary objectives are illustrated. Subsequently, the service-oriented architecture, its components and the web-based environment are presented, which serve as an enabler of the previously illustrated long-term objectives. All aspects taken together constitute Campus.UP – the approach, architecture and platform proposed in this article.

3.1. University-wide IT services

The ICT organization at the University of Potsdam missed-out on some developments and shifts between the years 2000 to 2012. From the point of view of the data center the most notable miss was a doubling in almost all indicators for the size of the university while the number of staff at the data center remained constant. This led to a highly dedicated guerrilla-like culture within the data center to keep system and infrastructure afloat and to provide reliably run-of-the-mill IT-services for the users at the university. The exception being the network and connectivity (including WiFi) that were always kept up-to-date. The usual shift from systems to services and serious approaches to service-orientation had not been attempted, nor was any IT-strategy in place or followed. The poor housing of the central IT systems being another point in missing developments.

Of the historically five faculties in Potsdam, only one had a distinct affinity for ICT. This might explain why on the one hand IT resources did not follow suite the expansion of the university, and on the other hand how the university was able to successfully operate without an adequate central IT organization. Those groups that had higher ICT demands created their own ICT systems in an unregulated manner; hence, there exists a culture of shadow IT in Potsdam.

In the past four years, several new systems were brought into operation, in parts with the help of large-scale projects in the wider E-Learning area. Amongst them are a data storage application, a media-server, a bunch of feature-rich Moodle systems serving particular needs (e.g. education in general, assessment platform and for international courses), several small e-learning apps (e.g. etherpad, clicker, information panels), a revamped communication platform (email, chat) as well as the known Shibboleth-based single-sign-on infrastructure. Furthermore, several systems supporting administrative tasks were introduced (e.g. business intelligence, online travel permits, online procurement). All systems and interfaces are geared towards mobile usage and are predominately open-source. These systems extend the existing ecosystem by some badly needed functionalities.

About one year ago, a reorganization of the internal structure of the data center was set in motion. This process is still ongoing. The aim is to move “Hey Joe” administration and “whole-stack” system administrators to a more manageable structure with specialized teams, IT service management being the ultimate goal. In the year 2011 the position of a CIO was established, in 2014 a first IT strategy was passed and there is a silver-grey lining on the number of staff as well.

3.2. The architecture of Campus.UP connecting single services

The architecture underlying the web-based virtual environment has already been proposed in 2014 (Kiy, Lucke & Zoerner). In the meantime, the architecture was extended by further components to satisfy the continuously evolving requirements, current trends and newly identified future needs. The architecture is service-oriented and is composed of two layers, each containing a special realization of an enterprise service bus (ESB), called the university service bus (see fig. 1).

The Private Service Layer provides the basis of the service-oriented architecture with a set of web services to central organizational units (e.g. library, student services, learning & campus management system), a process engine handling cross-system processes as well as some specialized databases and services (see fig. 1).

While the Private Service Layer encapsulates all university-internal services and connects them to the ESB, the Public Gateway Layer in contrast provides possibilities to connect different user interfaces, third-party services and tools to the underlying infrastructure. This opens up possibilities to reuse the provided APIs to implement solutions for various new use cases, like public information panels, mobile applications or more sophisticated workflows or systems. Once a web service and workflow is implemented, it can be reused in any kind of application, be it on a web page like Typo3 or in a mobile application. The proposed architecture may also be used as a basis for cooperation across higher education institutions, since it abstracts from dedicated implementation details and specific services. The StApps project, which tries to provide a cross-institutional mobile application, uses a similar approach (Lehmann & Huber, 2015). This implies a consequent interface, protocol and format abstraction on the infrastructure, platform and software level (cf. IaaS, PaaS, SaaS) for all thinkable services (e.g. storage, authentication, e-mail, calendar). As an example, storage can be connected on an infrastructure level via S3 (Simple Storage Service) and via WebDAV (Web-based Distributed Authoring and Versioning) on a software level.

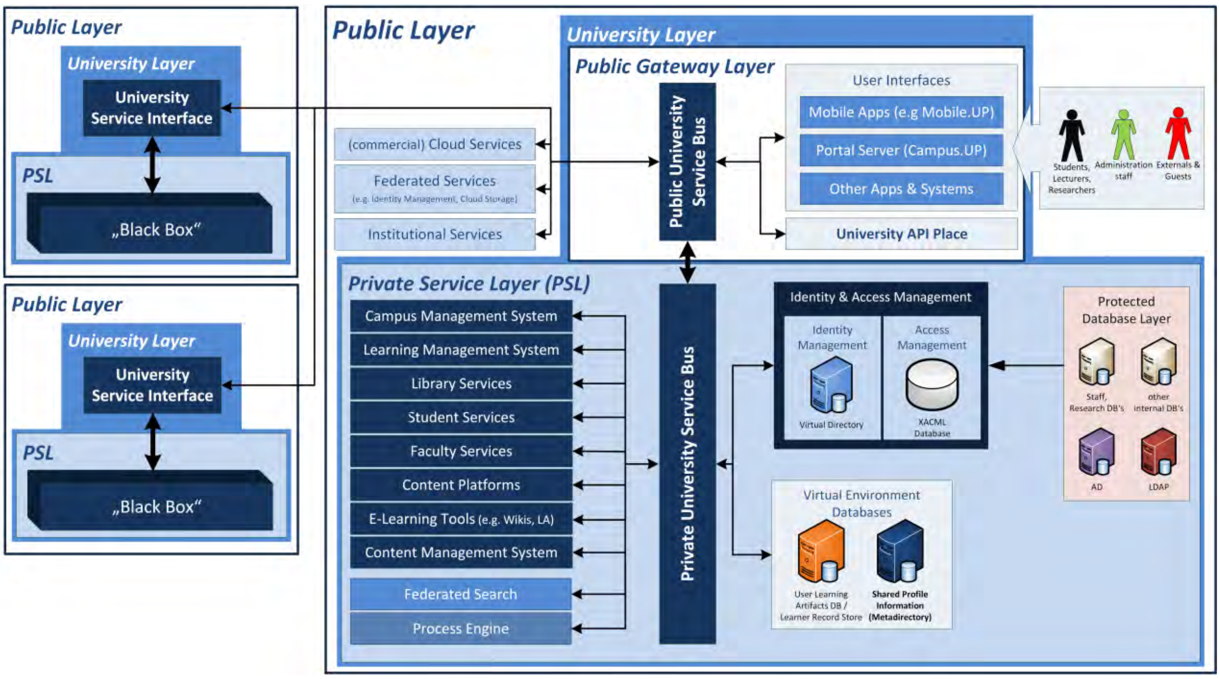

Figure 1 - Campus.UP's architecture with the two different layers and a subset of its components, databases and interfaces

A crucial requirement for combining single services in order to provide high value services is the initial determination of the essential ICT systems and services of the institution. After they are identified, the next step is to define reusable and abstract service interfaces, or if already existent, to make them accessible by other applications. From then on, the services can be used in any kind of application and can be mashed up in one portal to address the complexity issues of the stakeholders and to simplify the tasks of the service staff at the same time. Furthermore, the different systems themselves have to be connected with each other by the use of plugins or connectors to support the resource transfer. On top of this, ways of integrating third-party applications have to be considered as well. As a result, central systems should be ready to be extendable by connectors enabling access to both central services and external services e.g. Dropbox, Google, Microsoft, Youtube or Social Networks. This will ensure at least a minimum opening-up of the institutional systems to the real-world experiences of the respective stakeholders.

3.3. Campus.UP – the platform for academic collaboration

Due to the use of a service-oriented architecture, services can be combined to create new high value services or applications. Therefore, on top of the previously presented infrastructure, several web-based and mobile user interfaces were implemented. Each interface, or rather application, uses a different set of services to fulfill the specific needs of the stakeholders (e.g. apps for study organization, apps to support student's introductory phase, research apps, information panels or classroom response systems). As a central access point, the web-based portal application Campus.UP was developed. Campus.UP tries to simplify and unify the access to the central ICT services and systems and provides a user interface for cross-system processes.

As presented previously, different approaches are used to implement virtual environments (Kiy & Lucke, 2016). At the University of Potsdam, a hybrid approach was chosen. On the one hand, the portal Campus.UP is the centerpiece of the infrastructure and reunites the various available services in one consistent, web-based user interface. On the other hand, the application Mobile.UP forms the mobile counterpart, providing the user with information and services, which are useful in a mobile context (Kiy, Geßner, Grünewald, & Lucke, 2015).

In addition to the previously conducted requirements analyses, a focus group analysis was added in order to better understand media-didactical needs and to derive use cases for learning, which have to be supported by a unified platform. By the combination of an interdisciplinary design-based research process (DBR) and by methods of the agile software development, the web-based platform Campus.UP has been designed and continuously further diversified. The DBR approach involves central e-learning stakeholders, lecturers and students. Therefore, the current state of the infrastructure is a result of an ongoing negotiation process and still leads to relevant developments.

Even if the mobile and the web-based implementations of the virtual environment are undoubtedly interesting, this article explicitly focuses on Campus.UP and the underlying infrastructure. Campus.UP is the access point to all services, systems and acts as the cockpit of the personalized virtual environment for students, teachers and staff. Therefore, the software, which had to be chosen, had to ensure the integration of different information resources, systems and services in one consistent interface. When it comes to the integration of information and implementation of virtual environments, the following web-based approaches are preliminary used (Kiy & Lucke, 2016): the extension of social software (e.g. MediaWiki, WordPress), the extension of institutional applications (e.g. Learning Management Systems like Moodle) or the use of widget- or portlet-based applications. However, the categories are not distinct and several systems already use widgets or portlets to encapsulate functions and information.

One central goal of the research project is to create a solution, which is transferable from one institution to another. Due to this decision, the possibility to extent a dedicated learning management system fell out of the equation, because such systems have to be replaceable like any other infrastructure component or service. From a developers point of view it was reasonable to choose a system, which uses well-known frameworks, libraries and technologies to ensure extensibility. Due to monetary aspects, a complete development from scratch was discarded as well. Instead, an open source project enabling further development was the preferred option. Any useful system has to deal at least with the crucial aspects of user authentication, role management, the management of resources and content; at best, it offers a broad range of plugins and extensions over a community-driven marketplace. Finally, as usual, it came down to the near-religious question, whether to use Java, Python or PHP as a programming language. Since nearly all web services are being developed using Java and more experiences and competencies were at hand for Java and its frameworks, Java was consequently chosen as the language for implementation.

After a short market analysis, several big players like JBoss Portal (http://jbossportal.jboss.org/), Liferay (https://www.liferay.com/), eXo (https://www.exoplatform.com/) or Jasig/Apereo uPortal (https://www.apereo.org/projects/uportal) were evaluated. Due to various reasons, like license restrictions, which limit further developments, ongoing costs and feature limitations, which would have had to be expensively implemented, an existing university community and test installations, finally the choice fell upon the open source enterprise portal Liferay. The software belongs to the branch of enterprise information portals, which provides a framework for integrating information from various sources. Another benefit of Liferay is the use of established background technologies like Solr or Lucene for search, Java-Caching technics, Business Process Integration, the support for a high availability or cluster setup, the utilization of a layered architecture, which is extensible e.g. by the use of web services and Liferay is highly customizable by various hooks and extensions. Caused due to the fact, Liferay is a content management system itself; it covers out of the box social software and functionality, like for example blogs, wikis, social profiles, a message system and chats. Thus, several media didactical demands for a virtual learning environment are covered already without any extra efforts.

Over several iterations, Campus.UP has been further developed. This entails the continuous update and change of the already existing and additionally built up infrastructure and its components. Step by step, central ICT components and systems are connected and thus integrated within Campus.UP. However, due to the fact that current stakeholders are primarily interested in independent and collaborative e-portfolio work, the current focus lies on the e-portfolio components. In Campus.UP every user owns private and public pages. In order to avoid unnecessary duplications with an external e-portfolio management system such as Mahara, it was decided to implement a generalized e-portfolio workflow, derived from various e-portfolio systems, within Campus.UP. Currently, users can create pages and in sense of the e-portfolio workflow can share pages and request feedback for sites, which can be given as an message, chat message, e-mail or during a live session (Kiy, Grünewald, Weise & Lucke, 2016). Some pages are preconfigured and not editable to ensure at least a basic functionality for all. From this starting point it is always possible to create own pages and populate them with so-called portlets. These portlets act as an integration bridge to the central ICT components. To embed functionality within Campus.UP different integration levels are used, either by framing different user interfaces (e.g. Mobile.UP) or by the use of web services or standardized protocols.

Up to now, different concepts of spaces so called workspaces have been conceptualized and implemented, each accentuating different needs. One workspace focuses the teaching aspects, one enables the group work as equals and yet another allows hierarchical communication scenarios as may happen in central administrative units. Each workspace is preconfigured with different pages, tools and services. So far, the group workspace, which all users share common privileges in, is available. Each user, despite whether student, teacher or staff, is able to create workspaces, configure them according to their needs and invite other users to collaborate, share resources, publish or present information. For this reason, Campus.UP is not only referred to as a learning environment but rather a learning, teaching or work environment.

4. Evaluation – User Scenarios

The work with e-portfolios in Campus.UP is focused on the possibilities to autonomously form groups and contribute in form of so called workspaces. In the meantime, most central services of the University of Potsdam are prepared for integration within Campus.UP. This includes the extension by web services based on standard and semi-standardized formats and protocols, the connection to the single-sign-on infrastructure and the definition of cross-system processes. However, since the current implementation focuses on learning a corresponding evaluation based on focus groups is presented. The focus group consists of educators from various disciplines like didactics, philology and cognitive science. As mentioned before, the design-based research approach is used as a development and research methodology, which directly ensures the continuous inclusion of feedback from focus groups to the agile development process.

With the help of Campus.UP several learning scenarios were realized. This includes the classic summative e-portfolio work, in which each student has to write an e-portfolio for a given period (i.e.

to accompany an internship), which then has be submitted for review or grading. Additionally, students can continuously request feedback on their e-portfolios at any time, which is rather used for ongoing semester courses. Furthermore, the platform's workspace concept is used to either provide independent spaces for group work associated with a teaching-course, enabling collaborate e-portfolio work, or to organize and support common course work.

In the course of regular meetings with the focus group, the requirements and the feedbacks after each semester are collected, redacted and then find their way into the development process. All learning scenarios could be implemented with the help of Campus.UP. However, it turned out that an increasing number of educators use videos as a starting point for reflections on experiences and situations during internships or work placements of students. Since the integration of the cloud-storage with Campus.UP is not fully implemented yet, it was cumbersome to upload videos and embed them into the portfolio pages. In particular, due to privacy regulations of recorded people, especially pupils in teacher training scenarios, the existing possibilities to share and embed videos, which are publicly available, cannot be used. Since e-portfolios are a form of formative and summative assessment, the results have to be archived in order to comply with legal regulations. Therefore, the lecturers need an option to export as PDF or print out the corresponding e-portfolio pages. The last crucial feedback concerning collaborative work with Campus.UP is associated with the management of guest accounts in the data center. Many persons collaborating with students and lecturers from courses are not affiliated in any kind with the institution like for example the mentors or teachers in schools or other persons who play part in the internships. So far, most communication is handled by e-mail and telephone. To improve this situation the possibilities to invite and collaborate with persons external to the institution has to be redefined in the ICT organization.

With respect to the interface and the usability of the platform, we did not receive any negative feedback. We attribute this to the fact that students and lecturers were always involved in the conception, in prototyping and in testing. Due to the continuous user evaluation and feedback, the demands regarding the e-portfolio workflow were rapidly integrated. For example, the students and lecturers asked to improve the notification system in Campus.UP. Therefore, the functionality to receive e-mail notifications in addition to the existing activity stream was implemented. Now, for example, students and lecturers get e-mails when sharing a portfolio-page, when asking for feedback or when an assessment of a page was done.

While more and more services like the learning management system, the cloud-storage and the video-platform get integrated in Campus.UP, the activity stream is overloaded by messages and notifications from the platform itself and from the connected systems like the learning management system moodle. As a result, filter functions with respect to connected systems and workspaces is being implemented. Furthermore, a redesign of the activity stream took place to stop information overload and distinguish whether the information is created by Campus.UP itself or an "external" system. All obtained results are generalized to cover at best all future scenarios of information publishing. All insights regarding user guidance, usability, notification management and the integration of services and processes will be agile refined, thus to be reused for the stakeholders like researchers or non-academic staff. The design-based approach with direct stakeholder participation is extended to other domains now.

5. Bridging between research-driven innovations and continuous operation

The project Campus.UP is the first project at the University Potsdam that seriously tries to integrate features and functions from different systems seamlessly into a service for a group of users at the university. It also introduces a service-oriented middleware that potentially allows combining existing systems and their features into new high quality services for further use cases. The ICT architecture and the according changes in the infrastructure as well as in the ways of conducting business at the data center and the ICT organization as a whole creates significant efforts. This poses the question on whether "we are doing the right thing" and leads to the million-Euro question what the aims of ICT services at a higher education institution should be, now an in the foreseeable future.

There are lot of opinions on this topic out there. Tracy Schroeder (2014) talks about a "post-enterprise concept" and states that "increasingly, the main challenge for higher education faculty, staff, and students might not be getting support from the enterprise IT organization but, rather, getting around the enterprise IT organization so that they can use the consumer apps they want." She identifies three other significant future areas but states that "without ensuring a base level of quality and efficiency in utility services, the IT organization will be precluded from contributing in any of the other areas identified […]. But this level of maturity is not easily achieved."

So ultimately, the ICT organization has to ensure the availability of safe-to-use utility services and at the same time innovate in order to meet future demands. Users may say that "I don't want you [the IT organization] to be a service provider in this situation; I don't even know what I want, or what is possible. I need you to create something with me" (Schroeder, 2014). Schneider (2016) concludes an article on the mission of a higher education ICT organizations with the statement that the "currency" of the ICT organization "is trust", in the sense it being able to fully apprehend the challenges the users face. So useful ICT services must be capable of creating individually tailored solutions for now unforeseen scenarios in the context of Academia, or at least be able to support solutions. This possibly leads to a paradigm that Dreyer et al. (2015) describe as "Anything as a Service" (XaaS).

The project Campus.UP constitutes a building block to tackle challenges and demands described above. Yet other innovations and changes will have to follow to create a future-proof ICT ecosystem. The question then becomes "are we doing things right?" The components used are open-source, which certainly helps in keeping developments under one's own control. To make innovations in higher education ICT a research area of Academia itself also seems a feasible option. However, both aspects pose risks and challenges.

We do not claim to fully deal with all risks and challenges when faculty gets involved in innovation processes at the (central) ICT organization comprehensively, but rather describe local experiences with this approach in the context of Campus.UP. We think about things around three topics: *Governance*, *Marketing and Finance* and *Sociological Aspects* without ever making them explicit anywhere. Our underlying answer to all questions will be "trust" and "communication".

One of the unsolved critical issues at the University of Potsdam is an immature ICT governance. This poses a problem in just about any situation, but with respect to faculty innovating at the institution-wide ICT one has to deal with conflicts as people already serving multiple roles possibly getting pulled into conflicting situation even further. The statement of Drucker (2008) "management is doing things right; leadership is doing the right things" can become mingled up beyond all recognition. A clear decision-making process, respective commitments and transparent prioritizing can be hard to come by in this situation. This is not a quite unusual situation at a university. Cohen et al. (1972) described this situation as a "Garbage Can Model of Organizational Choice". However, the situation becomes aggravated when faculty start innovating from their expert point of view, but other flanking measures that should accompany major changes (like an appropriate change management process) lag behind. This situation can easily happen when faculty on the one hand is eager to push their ideas and do have the funding to conduct their expertise part of the innovation, but governing bodies distrust those ambitions and do not release any further funding.

The difficulties then lie in a distrust between the focuses of the groups involved in the process. The data center staff may feel that the faculty staff are striving for a once-off success story on the completion of their project, whilst the faculty staff sometimes do not fully comprehend the data center staffs' dedication to the reliability of their systems. Yet further trust has to be instilled in the data center-side of things from management or leadership (choose appropriately). The data center have to trust that they are (not again) being left alone with growing demands and complexity issues that could potentially undermine the reliability of the then underlying IT systems. To ensure the reliability of systems and services a lot of routine has to go into the daily "production". Major changes in organizing this production alongside with the introduction of new technologies pose a threat to those routines. To make the project Campus.UP a sustainable success at the university, a lot of distributed knowledge from within the ICT organization (and possibly beyond) has to be pooled and responsibilities have to be shared. This constitutes yet another cultural change away from the guerrilla-like dedication mentioned earlier. Hence, accompanying measures to manage the changes have to be taken. Dreyer et al. (2015) describe a similar challenge when introducing an open-stack environment: "Where managing techniques are changing, also new knowledge and new skills have to be built up and incorporated into the daily process", i.e. the new tasks and ways of working ("from operating to managing"?) and even change in itself have to become routines.

Trust-instilling measures should of course happen (and be promoted) on the personal level between people of all groups of stakeholders. This however does not sufficiently address the different planning horizons and focuses inherently to the different groups in question as well as their necessarily different way of working. In order to be able to gauge new projects (approved in- or outside the ICT organization) with respect to their values and risks for the targeted infrastructure, a roadmap or a program for necessary, desired and innoxious innovations is needed. Ideally, such a roadmap derives from the IT strategy or via some business IT alignment and obtains commitment from governing bodies. This will then form the basis for suitable measures in the ICT organization like the establishments of an architectural framework, a technology portfolio as well as a suitable project structure.

Often enough projects are started under the flag of being "lighthouse projects", with the hope of them being followed. This then may or may not happen for various reasons. However, if these things happen at the infrastructure level it becomes dangerous. One way to alleviate the situation would be to equip the data center with enough own developmental power to enable them to innovate along the critical paths themselves. The extra resources and projects from faculty could then be used to speed up or improve things. The alternative approach of externalizing innovation has its charms therein that external consultants might have more luck in convincing leadership or management to go with a more holistic approach. This may happen because they can sell matters better (instill more trust), but sadly it may also be down to the general culture of distrust and greed within universities. The "Prophet in His Own Country" syndrome may also play part here. We can also not exclude the possibility that the amount of money involved when going external focuses management's attention better than research-funded in-house developments.

From the point of view of sheer results, one would expect that faculty-aided on-campus developments, hopefully with partners in other institutions, deliver better and more sustainable results – if done under the right conditions. The chance of them failing badly or not being sustained due to issues grouped around distrust and missing commitments is high.

One could discuss whether an "in-house" or an "external" variant is better suited when innovation is either incremental, radical, evolutionary or disruptive (Clayton 1997). However, we believe that in order to add value to higher education institutions through innovations in ICT the issues presented above have to be tackled in any case. Maybe in today's world, where "good work" counts for little and success is everything, a common "success story" for all involved has to be created. A good narrative could form the basis for many good things stemming from good work.

6. Conclusion & Outlook

This article started with a requirements analysis and the derived objectives, which have to be tackled by ICT for successfully acting now and in the future. Considering the past and present developments at the University of Potsdam, the future developments were outlined and a service-oriented infrastructure, its corresponding services and the platform Campus.UP were presented. In addition, corresponding evaluation results of the current focus group, which concentrates on e-portfolio work, have been presented and the results were arranged in the order of the next steps necessary.

The current findings indicate a tremendous demand of new solutions (software, tools and services) to tackle new, and not yet conceivable scenarios in research, education and daily student life. Since the platform Campus.UP already supports several social aspects (e.g. networking, profiles, workspaces), it can be easily extended to be used as an intranet or service platform of the university. While the past steps explicitly focused on learning and e-portfolio scenarios, the future development steps will deal with extension of Campus.UP to more institutional scenarios. Therefore, the work of central units, student representatives and committees will be supported.

Further developments will deal with cross-system and cross-device support. This includes the seamless shift from one device to another and therefore aims to dissolve the distinction between formal and informal respectively non-formal experiences. Systems and services have to be available everywhere and at all times, no matter in which personal context the user interacts. In this regard, the mobile application Mobile.UP will be extended to act as a mobile sensor node, enabling the access of the most used services on the one hand, but also to collect valuable context information of the user on the other hand. The context information will be used in Campus.UP to provide a more personalized feeling, e.g. to provide tool recommendations, synchronize the working state of the mobile and the web portal and to adapt the user interface to the specific needs of the user.

Campus.UP and its corresponding infrastructure is only seen as an interim step of providing a service-oriented scalable infrastructure enriched with software, services and tools, which supports the individual needs of the different stakeholders of universities at its best. However, a platform can only be as good as the basis on which it stands. Every promising approach and innovation only has a chance to stand the test of time, if it manages to leap from the state of a research project to establish itself persistently as a service. For this to happen it must be transferred and adopted as a sustainable routine in the data center. While requirements increase and more complex systems and infrastructures evolves, data centers have to adopt their perspectives and find new ways of providing infrastructure, tools and services (e.g. hybrid cloud infrastructures) (Moeller 2016). In a decade where everything as a service lurking around every corner, data centers (and ICT organizations of academic institutions as a whole) have to be systematically put into the positions out of which they can move to provide crucial services for knowledge-based enterprises like higher education institutions in the era of digitalization. In this context, a paradigm shift from operation to management and new ways of providing and maintaining ICT infrastructure are be needed. In order to ensure competitiveness business and operating models (in house, hybrid or external) have to be taken under consideration. Both the use of (hybrid) cloud services and cross-institutional cooperation (regional, national and international) on all aspects of ICT can on the one hand free valuable resources, but is probably more fundamental to sustaining efforts. After all, good ICT-solutions, tailored for Academia, if not exclusively but in large, structurally independent of commercial offers, will form the basis of successful Academic work in the future.

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InkluTeach: A Virtual Classroom for Pre-Service Teacher Training

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Keywords
360°video, Virtual Reality, eLearning, Inclusion, Pre-service teacher training, Virtual Classroom

1. SUMMARY

This Paper reports an exploratory project in which we designed the innovative eLearning platform *InkluTeach* for teaching pre-service teachers by implementing 360° videos with real classroom scenarios of inclusive learning of children with and without special education needs. By the use of 360° video in combination with virtual reality (VR) headsets we create a virtual classroom, where the pre-service teachers become part of the situation they have to analyze. The paper gives an overview about possibilities and challenges for new video technologies in the field of pre-service teachers training within this project.

2. INTRODUCTION

Worldwide, the implementation of an inclusive school system, which is prepared for the distinct heterogeneity of pupils - with and without special education needs or intellecutal gifts - is a big challenge. The basement to achieve success in this transformation is a long and significant process of reorientation of the teachers' beliefs and attitudes as well as of their occupational profile and professional ethics. In addition, teacher training at universities has to develop skills for working with heterogeneous learning groups.

Numerous studies show that novices are likely to suffer from a "reality shock" when starting their professional career as teachers (Müller-Fohrbrodt, Cloetta & Dann 1978; Stokking, Leenders, de Jong & van Tartwijk, 2003; Zingg & Grob, 2002). Apparently, novices experience difficulties in transferring theoretical knowledge into school practice. Renkl (1996) spoke about "inert knowledge" - knowledge which is not available for practical use in school. Regarding the pre-service teacher training at universities, Gerstenmaier und Mandl (2001, p. 1) pointed out an immanent abyss between knowledge and action. Thus the current situation of the pre-service teacher training at universities is critical. In this project we try to solve this problem by providing videobased learning.

3. VIDEO-BASED LEARNING

Using videos is a very useful method to train pre-service teachers with educational content. During the sixties and seventies, classroom interaction analysis and video recordings for teacher education became very popular in the USA (Wyss, 2014). Because of the steadily falling costs for camera and audio equipment, new technical improvements and the development of new information and communication technologies (ICT), video based learning became a standard in teacher education from the middle of the 1990s (Helmke, 2012). Until today, video is often used in teacher preparation programs. The medium video provides the huge complexity in real classroom situations so that students can reflect, analyze and evaluate lessons from different prospects. By working with videos students get an initial practicable access, substantiate theoretical and accumulate practical knowledge (Brophy, 2004; Goldman, Pea, Baron & Denny, 2007; Krammer & Reusser, 2005). These possibilities indicate a flexible and continuous commitment, as well as a practice-related access (Mayring, Gläser-Zikuda & Ziegelbauer, 2005). Several studies showed that working with video offers great potentials to develop and sublimate professional teaching. Mostly these videos focused on the teacher or the class (Digel, Baust & Schrader, 2014).

Irion (2010, p. 141) criticizes that information for the analysis of videotaped teaching processes frequently is missing because it is outside the camera perspective (framing). For objective observation, as well as analysis and assessment of a situation, this circumstance appears to be highly problematic. As a solution, Goldman (2007, p. 4) suggests the use of several cameras. In fact, he claims that the aim of using those video technologies is to embrace diverse points of viewing to prevent the hazards of bias, misrepresentation and missed-representation. The advantages of several perspectives are also embedded in many participatory researches. From these perspectives, several cameras are the preferred option. But on the other side some researcher (e.g. Heath et al., 2010) suggest that the use of multiple cameras is not advisable as they multiply the data collected, can overcomplicate the interaction by using multiple perspectives, can fracture sequences of interaction and present challenges for analysis (Hewitt, 2012, p. 16).

4. INKLUTEACH

To solve this problem, we developed the eLearning platform *InkluTeach*. *InkluTeach* is a video based eLearning environment, framed and complemented by corresponding theoretical knowledge and learning tasks. The platform should be used by pre-service and in-service teacher trainings in preparation for inclusive school practice, managing diversity, inclusive based or special needs educational tasks / materials as well as inclusive school development processes. It can be used for evolving and enhancing competences of observation, analysis and reflection.

The core of *InkluTeach* is the use of 360°videos to show pre-service teachers realistic “classroom practice” (Sago 2003). While in traditional videos, the user is locked to the angle where the camera was pointing to during the capture of the video (framing), 360° videos are video recordings where a view in every direction is recorded at the same time. “With 360º videos, we are able to deliver an even richer and larger quantity of information than before, that can span all over the viewer.“ (Neng & Chamble, 2010, p. 119). A "before and behind the camera" doesn’t exist anymore and multi-perspectives therefore become superfluous.

For watching and analyzing the video content we developed a multiview 360° video player with some additional features for 360° video analysis (e.g. time makers, grid lines and logbook). By the use of 360°video in combination with virtual reality headsets we create a virtual classroom, where the pre-service teachers become a part of the situation. This offers many opportunities. By the use of multiple perspective, it is possible to prevent the “reality shock” of novices. We presume that students will be better prepared for working in inclusive learning settings.

In our presentation we will present the function and the structure of *InkluTeach*. We will show some examples of our 360° video content and player to discuss the opportunities, challenges and the high potential of new ICT´s (e.g. 360° video, VR) in the field of pre-service teacher education.

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Experiencing the 'smarter' campus

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Keywords
Smart campus, student experience, learning spaces, audio-visual, standards.

1. SUMMARY

It seems that every few years a new development (usually featuring technology), be it online learning or, more recently, MOOCs, heralds the 'death of the university campus'. The physical evidence however always appears to contradict these predictions. Campus education continues to be relevant because learning is a social process but the nature of the facilities we need to provide is changing significantly.

This paper looks at trends in the use of digital technologies on-campus and the organisational and management issues they pose. We concentrate primarily on the use of such technologies in spaces used for formal and informal learning and teaching. The paper makes the case that successful integration of digital technology is key to delivering excellent learning experiences on campus and we make recommendations as to how the EUNIS community can take steps to help develop smarter campuses in their own institutions.

The authors are professionals who have supported a range of different universities in various aspects of learning space development. In the Congress presentation that accompanies this paper we illustrate the points with worldwide examples.

2. INTRODUCTION

It seems that every few years a new development (usually featuring technology), be it online learning or, more recently, MOOCs, heralds the 'death of the university campus'. The physical evidence however always appears to contradict these predictions. Universities across the world are investing as much as ever in the physical estate and even virtual providers such as Coursera have been moved to develop physical learning hubs. Campus education continues to be relevant because learning is a social process but the nature of the facilities we need to provide is changing significantly.

Digital technology is now all pervasive in universities. There is no aspect of learning, teaching, research, administration or campus management that does not rely on IT systems. The challenge now is to make these systems work seamlessly together so that we truly develop 'smarter campuses'.

'What do we mean by the 'smarter campus'? Words such as smart, responsive and intelligent are often used interchangeably and mean many different things to many people. In its widest sense the term smarter campus encompasses a range of technologies supporting many different business functions relating to building management, environmental and access controls and monitoring and tracking of activity. The terminology smart and intelligent when applied to buildings often means a focus on efficiency. In the case of universities we are also beginning to look at how the application of technology can make the people on the campus behave in smarter, more intelligent ways.

To address the topic fully would require consideration of how the Internet of Things, artificial intelligence and learning analytics might impact on our day to day activities. For the purpose of this short paper and accompanying presentation, we have decided to focus on the use of digital technologies in spaces used for formal and informal learning and teaching because these are issues that are important to all universities right now. They are also issues that are already blurring the boundaries between different professional services in universities and, importantly for the EUNIS audience, involving IT services in projects where some of the technologies and standards may be unfamiliar. This paper therefore looks at trends in the use of technology on-campus and the organisational and management issues they pose, concentrating primarily on spaces used for formal and informal learning and teaching. In the Congress presentation that accompanies this paper we illustrate the points with worldwide examples.

In the UK there is an increasing focus on what is termed the 'student experience'. The term pops up in mission statements, strategies and job titles of senior posts. Whilst the quality of learning and teaching is paramount, the quality of on campus facilities has an important role to play in defining the student experience. What today's students want to experience is a fully integrated, digitally enabled environment where multimedia and immersive environments are as much a feature of learning as our beloved books.

'*By elevating experience over technology, innovative higher education institutions create the advanced learning environment that attracts the best students and helps them to achieve their full potential.' (infoComm 2017)*

Digital is the new norm in many areas of our lives and this is equally true of pedagogic practice. There is now good evidence that the use of digital tools makes for active and engaged students and enhances their ability to learn. This has major implications for how we design formal learning spaces such as classrooms and lecture theatres. It is no longer sufficient that 'consumers of information' can see and hear adequately in the spaces. Students and researchers now want to interact, modify and share information and engage with wider learning communities using digital tools. The convergence of the physical and virtual environments is an important trend as is designing campuses where a continuous flow of formal and informal learning can take place.

3. LIBRARIES AND LEARNING CENTRES

In the digital age access to *information* is no longer a reason to bring students to campus thus the continued importance of physical learning spaces lies in them being able to support learning activities that cannot happen in other ways.

The trend towards new types of learning space supporting socio-constructivist pedagogies, such as active, enquiry-based or problem-based learning, began in the late 1990s and the early years of the new millennium with the development of new types of library and learning resource centres. There are now many excellent examples of libraries and learning centres that provide students with easy access to all the resources they need. Resources are available (physically and virtually) 24x7; ubiquitous wifi makes it possible for students to use resources and collaborate with peers on their own devices (laptops, smartphones etc) and there are university devices for those who do not have their own equipment. The environment is comfortable and welcoming with a variety of work spaces to meet different needs - silent study, collaborative group work etc. Food and drink are readily available and a lot of informal learning takes place in the social spaces.

Libraries and learning centres have led the way in creating new types of learning environment and many other parts of the campus have been slower to catch up. In the Congress presentation that accompanies this paper we will however look at some excellent examples of where the use of technology has enabled new types of learning experience.

4. FORMAL TEACHING SPACES

The design of many lecture theatres and classrooms has changed little over centuries. The layout assumes a *transmission* model i.e. one person will transfer information to others, who will all absorb it at the same rate, by focusing on the person at the front. One reason the lecture has survived both the invention of the printing press and the computer, is that the built environment makes it difficult to teach in any other way. The way in which space is designed shapes the learning that takes place. We need to rethink the types of learning students undertake in these collective situations.

Increasingly mobile and affordable technology offers new possibilities to design types of learning activity that encourage students to create as well as consume learning resources and to collaborate in new ways. Convergence of the physical and virtual is a significant theme in new learning space developments.

Traditional lecture theatres remain useful for teaching large cohorts and they are being adapted to new teaching practices e.g. the introduction of swivel-seating to allow students to turn and work in groups and the use of technologies such as personal response systems to allow interaction between students and lecturer. Lecture capture is enabling developments such as *flipped classroom* where students listen to the lecture in advance and use the face to face time for interactivity with the tutor.

Classrooms are being fitted with lightweight furniture that can be easily reconfigured to support group working and low-tech solutions such as writable walls are very effective in supporting collaboration. Digital technologies can also help increase the flexibility of the space as light, sound and projection can create a different ambience at different times.

Changing traditional teaching practice is less easy and academics may need support to help them work in different ways. It can be uncomfortable to teach in an innovative group space without a clear idea where is the *front* of the class. Many lecturers fear that lecture capture means students will no longer attend class although evidence suggests interactive lectures are well-attended. Students may also need help to adapt to a less passive role.

5. ENHANCING EMPLOYABILITY

The trend in the UK towards high tuition fees (funded by student loans which have to be repaid) has focused attention very firmly on the practical benefits of higher education in terms of future career prospects. Student employability is however an important theme across the rest of Europe as well. Business leaders are clear about the kind of attributes they want to see in graduates from higher education: analysis and problem solving, collaboration and teamwork, business-context communication, along with flexibility, agility and adaptability. These are precisely the type of attributes that active learning approaches can foster.

Many leading universities place great emphasis on having state of the art technologies that mirror those used in business and the presentation that accompanies this paper will illustrate some examples of this. The integration of innovative AV experiences is an important factor in preparing graduates for the real working environments they will experience.

Physical space can promote better learning but we also need to design learning *activities* that give students the problem solving skills needed for employment. An example is scientific disciplines moving away from *recipe based* experiments (following a formula to achieve a known outcome) and encouraging students to design their own experiments to solve problems. Technology has a role to play e.g. games/simulations can develop problem solving and communication skills as students can make mistakes, free from consequences and failure is a recognised and accepted part of the learning process.

6. OTHER LEARNING SPACES

Ubiquitous technology means that just about any space on campus can become a learning space. The issue of creating a physical environment conducive to learning therefore extends beyond formal teaching space to other areas. Students spend a lot of time *hanging around* so equipping circulation space to facilitate self-directed learning is important. Otherwise such spaces simply reinforce the message that students do not learn until they move into formal learning space with a tutor present.

Digital signage is increasingly important on campus and audiovisual displays in public areas help generate a buzz by being informative, entertaining and helping create a sense of community.

7. FUTURE DIRECTIONS

The use of simulations and gaming type environments in education has been around for many years. Some of the best examples in the UK occur in vocational education.

PROCAT uses virtual reality (VR) in its electrical training for apprentices. A simulated environment allows the apprentice to move around a house. If they fail to observe required safety protocols when carrying out a task, the VR goes off with a bang without risk to the apprentice. Tutors find that apprentices learn more quickly when they can be allowed to make mistakes. PROCAT is also implementing VR in plumbing and construction and cybergloves in hairdressing.

By using virtual and augmented reality, S&B Automotive Academy has reduced the time allocated to training apprentices in paint spraying techniques and made cost savings of at least £13,000 per annum in terms of teacher time and consumables such as paint. Read the case study.

Higher education institutions are now beginning to show increasing interest in the application of virtual and augmented reality on campus e.g. the University of Exeter already has an augmented reality campus tour.

With the tools to support virtual and augmented reality ranging from highly sophisticated simulations to smart phone apps and Google cardboard we can expect to see greater use of these types of AV technologies in many situations in future.

8. IMPLICATIONS FOR IT AND SUPPORT SERVICES

The richer the digital environment becomes the more boundaries between the different professional support services in universities become blurred. Whereas AV and IT used to be very separate functions there is now considerable convergence. This convergence occurs in terms of infrastructure as the more facilities go digital the more demands they place on the network. BYOD is an area where what is possible using digital tools and devices needs to be carefully handled in relation to what represents good practice in network management.

We are also seeing increased convergence in terms of teams and roles. There is a, fairly understandable, tendency for senior managers to see that digital is the way forward for AV facilities and therefore assume that the function can simply be rolled into existing IT support. This is a somewhat shortsighted view that underestimates the amount of specialist knowledge required to get the best from digital AV and create an outstanding on-campus learning experience.

The picture is further complicated by 'smart campus' technologies that extend into the estate management domain such as digital signage, access control and building management services such as environmental controls.

Close collaboration between AV, networking teams and other support services is certainly needed. Often there are significant change management aspects to creating new service delivery teams. It is also not uncommon for different professional services to come into conflict over campus development projects.

'*Often, AV people see the network people as the people with the firewalls and the rules that stop their cool gizmos working, and networking see AV as having unmanaged devices with no authentication that break their security policies*.' (SCHOMS *et al* 2016)

Some institutions are taking the approach of situating responsibility for all digital devices within IT services and extending training for IT staff to encompass more audiovisual expertise.

In many European countries there are different professional associations representing AV and IT staff (often with yet another association for learning technologists) so that a broad organisation such as EUNIS can provide a useful forum for debate, exchange and updating across the full range of relevant services.

9. THE IMPORTANCE OF STANDARDS

IT people are generally knowledgeable about the existence, and importance, of standards in their own area of work. Discussions within the EUNIS community however indicate less general awareness about the range of design standards relating to AV technologies (and discussion with AV industry profesionals suggests that standards are indeed less established and developed than in many other industries).

InfoComm is the trade association for the AV industry worldwide and, as an accredited standards developer, it sets the standards for the industry. InfoComm works closely with the AV professional associations in higher education in many parts of the English-speaking world and it appears as though greater awareness of its role would benefit the EUNIS community. The references section of this paper includes links to some of the InfoComm guidance that is freely available to the higher education sector.

10. MANAGING A LEARNING SPACE PROJECT

Many learning space projects tend to go through their own version of the [Gartner hype cycle] that is to say initial ideas lead to inflated expectations that ultimately descend into the trough of budgetary disillusionment.

There are various reasons why this type of situation occurs so frequently and many of them relate to the relationship of AV and IT with projects that are often led by other parts of the institution. The two key issues are:

- AV and IT professionals are not brought into discussions sufficiently early in the project and often major design decisions have been made before they hear about it.
- Budget overruns are common and when this happens project leads often look to make savings on AV and IT equipment that is installed in the later part of the project life cycle.

The UK Higher Education Learning Space [Toolkit] (SCHOMS *et al* 2016) contains some very good guidance on managing learning space projects. It looks at topics such as:

- bringing the right people to the table from an early stage;
- techniques to aid both creative thinking and practical requirements definition;
- transitioning to new ways of working and evaluating their success.

Every learning space project is unique; there is no template that will apply to all situations but by taking inspiration from elsewhere, involving the right people and following good practice guidance you can deliver innovative solutions that will improve learning and teaching in your university.

11. RECOMMENDATIONS

This paper makes the case that successful integration of digital technology is key to delivering excellent learning experiences on campus and we have the following recommendations to make to the EUNIS community:

- Be proactive in suggesting the benefits that a smarter, more digitally enabled campus can bring to your institution. To do this it helps to be aware of developments elsewhere including seeking out the very best examples on a worldwide scale.
- Recognise the full range of professional skills needed to deliver successful outcomes and try to achieve the right blend of IT and AV skills in your support teams.
- Recognise the importance of design standards in both AV and IT areas and seek to implement good practice by following recognised standards across your campus.
- Make good use of links to professional associations and authoritative guidance materials to keep your staff up-to-date in this rapidly changing area. The sources mentioned in the references section of this paper are a good starting point.

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Teaching Media Literacy and English as a Lingua Franca: Learning by Doing International Projects - An Approach to Teaching Professional English in Higher Education

The advent of global citizenship in the 21st century posited intercultural communication and the need for efficient communication as the cornerstone of teaching English as a foreign language. Global digitalization has not only influenced how people communicate world-wide but has given higher education institutions the task of preparing learners for the global market.

English language teaching goes beyond a good command of linguistic structures to equipping learners with the competencies to perceive and understand cross-cultural differences and collaborate and negotiate meaning. Nowadays it is unarguable that communication is increasingly digitally mediated and for students to be competent communicators and get ahead in the workplace, they need digital skills. The challenge is to develop these digital and media literacies parallel with teaching English by promoting collaborative problem solving in technology-rich environments using English as a Lingua Franca (Seidlhofer 2005). This includes the ability to create and communicate digital information, the ability to research and evaluate information online, and the ability to solve problems in technology-rich environments. It also requires teaching learners to build strategies to enable a multitude of literacies to work hand in hand. 21st century competencies require learners to experience real-life tasks in authentic scenarios that are complex (Hallet 2014). Learners use media and Web 2.0 tools to communicate and collaborate with others and create joint knowledge (Dooly 2008) using English as a Lingua Franca (ELF).

This paper aims to provide an overview of the data and analysis of a telecollaboration project between three universities that focuses on teaching 21st century competencies. The European Dialogue Project (EDP) started in 2013 and has given students from Germany, Italy and Portugal the opportunity to work jointly online and developing new skills and different literacies. After four successful years, we have developed an approach to teaching professional English using technology and ELF, as well as examining how technologies are best used for learning, more specifically Web 2.0 skills. Furthermore, we have developed a set of guidelines in designing and implementing student collaboration projects for higher education institutions.

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Student experience and advancements in the academic on-line foreign language teaching at the University of Warsaw

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Keywords
e-learning, Higher Education, e-course, foreign languages, on-line teaching, life-long learning, innovation.

ABSTRACT

It has been 10 years now since the University of Warsaw students could try to learn a foreign language (English in particular) via the Internet using the university educational Moodle platform maintained by the Centre for Open and Multimedia Education of the University of Warsaw. The initiative was undertaken within the 2020 Bologna Process strategy for Higher Education, focusing on the enhancement of the innovative life-long learning systems, mobility, multilingualism and employability empowering. All these lead towards obtaining qualifications through flexible learning paths. As a result, progressively, multi-level and multi-purpose e-courses together with on-line placement tests have been created. They were used by 5 000 users in 2016 and by more than 40 000 e-course participants since the beginning of the project. The paper presents the way in which the concept of online foreign language teaching has been evolving at the University of Warsaw. It focuses on the pilot edition of the on-line courses of English, examining student speech recordings to practise the skill of speaking, that has been launched within the current academic semester (summer 2017).

1. Introduction and background

An on-line foreign language teaching project was launched (in 2006) at the University of Warsaw. It was led by the University Centre for Open and Multimedia Education and based on the use of an IT educational Moodle platform and the extensive application of the EFL (English as a Foreign Language) e-learning methodology. The main drive for this innovation were the goals of the 2020 Bologna Process strategy implemented by the European universities, which aimed at the improvement of the learning environment and removal of the study barriers by introducing, among others, student-oriented programmes, enhancing innovation and exploiting the potential of digital technologies. As a result, the modern didactics moved toward the ICT supported courses at the University of Warsaw, offering students various forms of learning. What is more, in accordance with the strategy, the Senate of the University of Warsaw issued a Resolution on equal access to the languages didactic offer for both stationary and extramural students. The process of introducing new forms of teaching foreign languages at the University of Warsaw let both stationary and extramural students have equal chances to master their linguistic competence.

To achieve satisfactory teaching and learning outcomes within the amount of teaching hours set in the curriculum, e-learning was introduced into the field of foreign language teaching at the University, with a particular focus on the English language. From that time on, the e-learning of foreign language courses has been progressively expanded. The courses were based on the existing IT infrastructure and the e-learning methodology worked out by the University Center for Open and Multimedia Education. Continuously, multi-level and multi-purpose e-courses together with on-line placement tests have been created (Pacholak, Galbarczyk, 2016). In 2016, 5 000 students took part in over 200 online language courses run by over 40 e-teachers (exceeding 40 000 e-course participants since the beginning of the project).

2. On-line English language teaching and learning and the services developed

A positive feedback from the academic community was delivered after the first edition of the e-courses at the University (Wieczorkowska, Madey, 2007). The tool used i.e. the Moodle platform, perfectly met the expectations for online English language teaching. It allowed for the application of all sorts of language teaching materials (audio, video, graphics, and text files) in one environment together with a variety of knowledge testing ways and it ensured immediate automatic feedback, decreasing the risk of inappropriate language learning habits (Clark, Mayer, 2016). A student-oriented approach helped learners to identify gaps in their knowledge that needed to be revised with greater care (Allen, 2016).

The on-line materials could be combined with in-class teaching (blended learning). They were also accessible on mobile devices, making the didactic process even more flexible for its users (Bednarczyk, Krawczyk, 2009).

Additionally, the plug-in integrating the University Students' Management System with the Moodle platform enrolment was launched.

Common access to both Internet and the use of ICT mobile devices fostered the development of computer-assisted e-learning courses within the academic community at the University of Warsaw.

As the first attempt, two courses in English were launched: *Writing summaries in English* and *The language of group discussions*. These courses were the starting point for a big project initiated for the whole university by COME UW in 2006, called "E-lektoraty" (Language e-courses), covering mainly the courses in English (but also in German, Russian and Croatian). What is worth emphasizing is that there were a few interweaving variables that decided about the current shape of online language courses at the University (Rudak, Sidor, 2008) and over a decade the online language courses have been constantly and regularly updated and redesigned, both when it comes to their language content and technical maintenance - to make them useful, varied and attractive for academic teachers and students. At present, 5000 students enrol yearly in online English language courses available on the e-learning platform at three levels of advancement: B1, B2, C1.

The e-classes of English contain the same, coherent language content at particular proficiency levels, structured in modules, run by over 40 e-teachers of the UW Centre for Foreign Language Teaching and the Centre for Foreign Language Teacher Training and European Education.

The online English language courses have served as a model for other courses like *Business English Communication* (run fully online without in-class meetings).

To facilitate the process of testing and evaluation as well as to help students find out about their language skills and choose the most appropriate course, the online placement test in English was embedded on an educational Moodle platform used in an interactive manner to obtain immediate results and instant feedback on the suggested choice of a course. Over 40 000 students used the placement test for this purpose in the years 2006-2016.

3. The structure of General English language e-courses

The concept and methodological assumptions together with the overall and detailed syllabi for the four Project modules were worked out by the expert ELT methodologists from the English Teacher Training College in the Centre for Foreign Language Teacher Training UW, contracted by COME UW (Galbarczyk, Walewska, 2006a).

Over time, these courses have undergone a number of changes resulting from the teachers and students' needs and feedback. The English e-courses are run as a parallel yet equally valuable option to the traditional in-class courses making it possible for students to enroll in a course of a preferred form.

As for today, the structure of a (blended) e-course is as follows:

- The modules provide language practice at two levels of advancement: B1 (two modules) and B2 (two modules). The C1 course is built according to a slightly different scheme.
- Each of the four modules (at B1 and B2) covers 60 teaching hours (a teaching hour = 45 minutes) and is organized the blended learning way with 45 hours taught via the educational platform and 15 hours – in a classroom.
- Each module consists of 10 thematic chapters. Every thematic chapter contains interactive exercises developing language skills: listening comprehension, reading comprehension, writing, as well as language sub-systems: grammar, vocabulary, functions and pronunciation (Figure 2.).

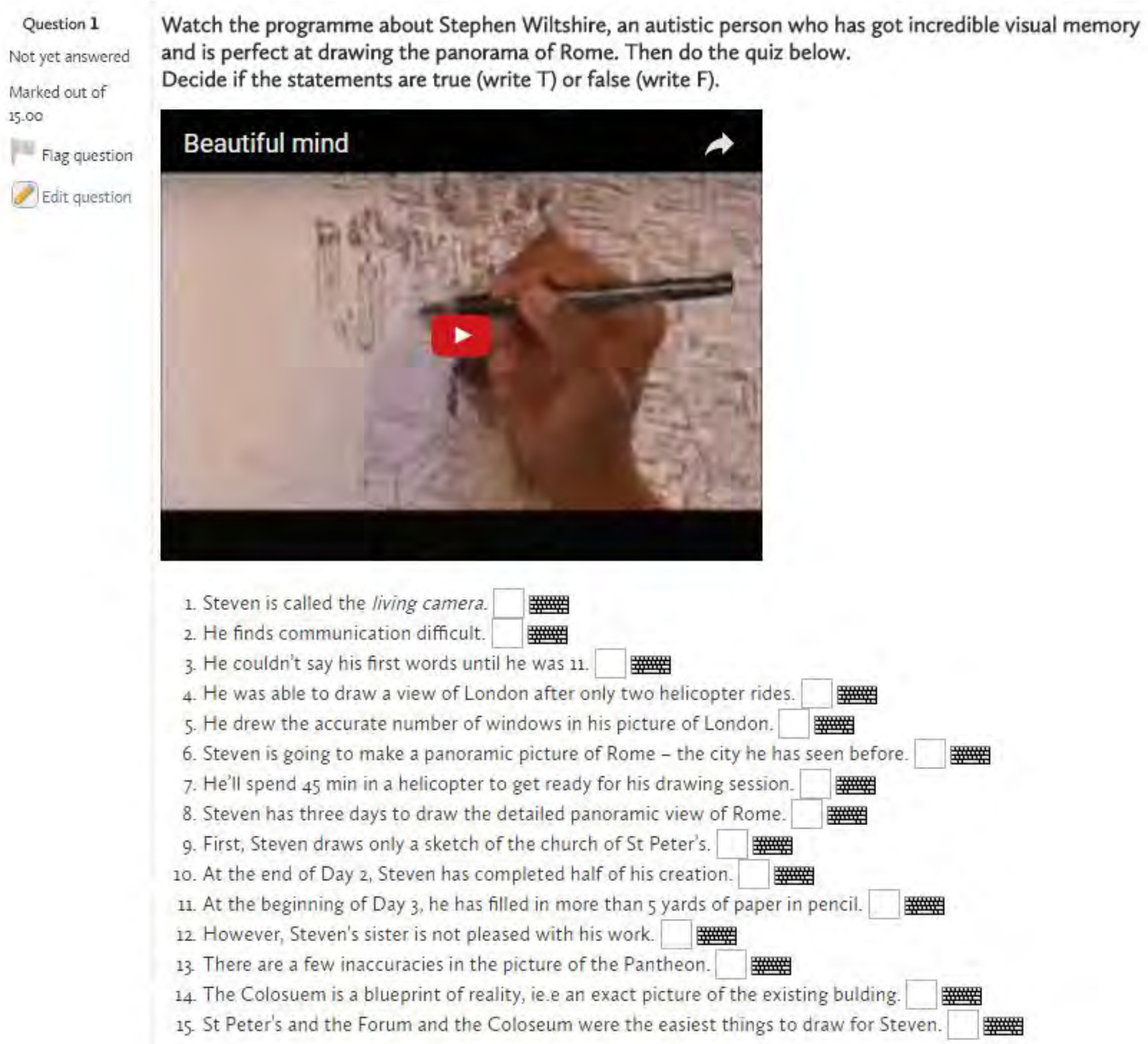

Figure 2. An example of an on-line listening task in a general English language e-course at B2.

The structure of each thematic chapter (Galbarczyk, Walewska, 2006b) reflects the most natural scheme applied in a real-life classroom – it begins with an open-ended warm-up task (usually in the form of a forum) introducing the theme and asking for students' initial reaction and sharing of experience. There are also follow up tasks to practise the language skills and sub-systems (in the form of interactive closed-ended quizzes). The chapter ends with an open-ended follow-up activity (in the form of a forum or an online/offline assignment, often including an academic writing task) (Figure 3.).

There is a revision after every second thematic chapter and a test section in a of a quiz with closed-ended tasks (evaluated automatically).

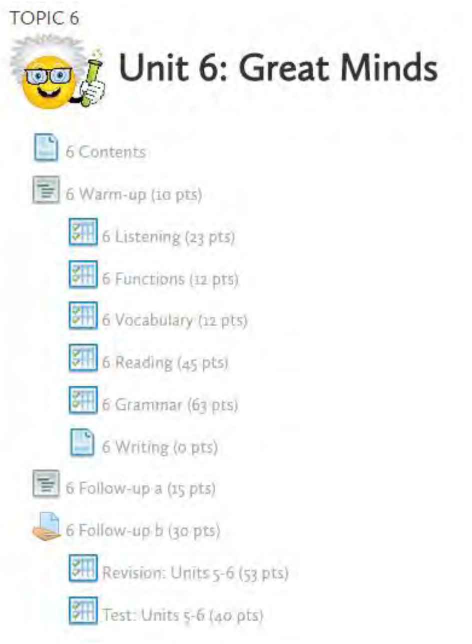

Figure 3. An example of an on-line module structure in a general English language e-course at B2.

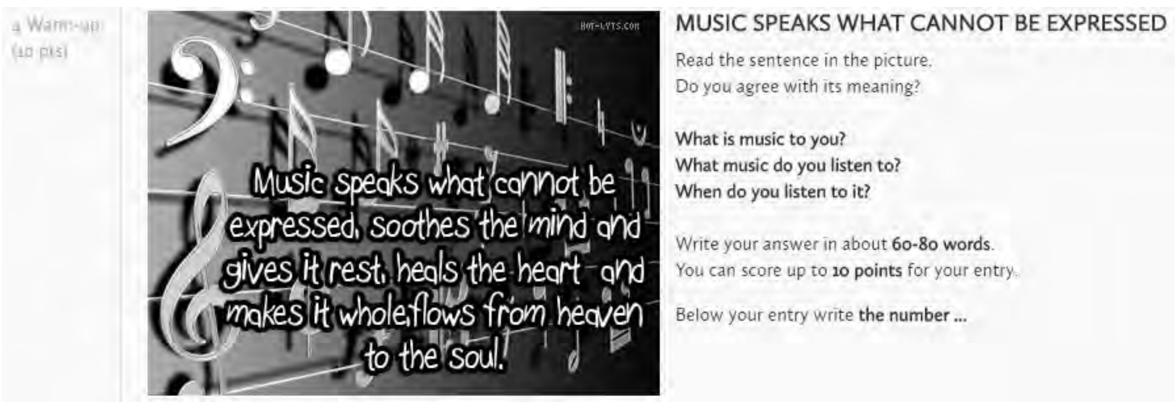

Figure 4. An example of an interactive assignment in a general English language e-course at B1.

The speaking skill, however, is quite difficult to be practised online due to asynchronous communication, and so it is dealt with only during the in-class meetings.

Even if the learning process is run mainly via the educational platform, the certification in every course is carried out in class.

Students of all faculties and types of studies may choose to participate in an online course or the traditional face-to-face classes. At the end of the semester, they complete the online evaluation forms placed within every course in order to express their opinion.

4. The “e-niche” identification

The student-centred learning requires the empowerment of individual learners, new approaches to teaching and learning, effective support and guidance schemes and a curriculum focused clearly on the learner. In order to meet the needs and opinions of students, the online evaluation forms are placed within every e-course. That helps further analysis of the changes/amendments that potentially could be introduced. In this way, a gap was identified in the speaking skills component within the e-course, as already metioned - quite difficult to be practised online due to asynchronous communication and dealt with mainly during the in-class meetings or via equivalent activities in the e-course forums. The evaluation questionnaires (run online for the last few years) have shown, however, that the development of the speaking skill is an important issue for students (no matter if they are stationary or extramural learners) and that the level of satisfaction with the speaking and pronounciation component is much lower in comparison to the other skills practice possibilities, such as: listening, grammar, writing, reading, vocabulary (Diagram 1.)

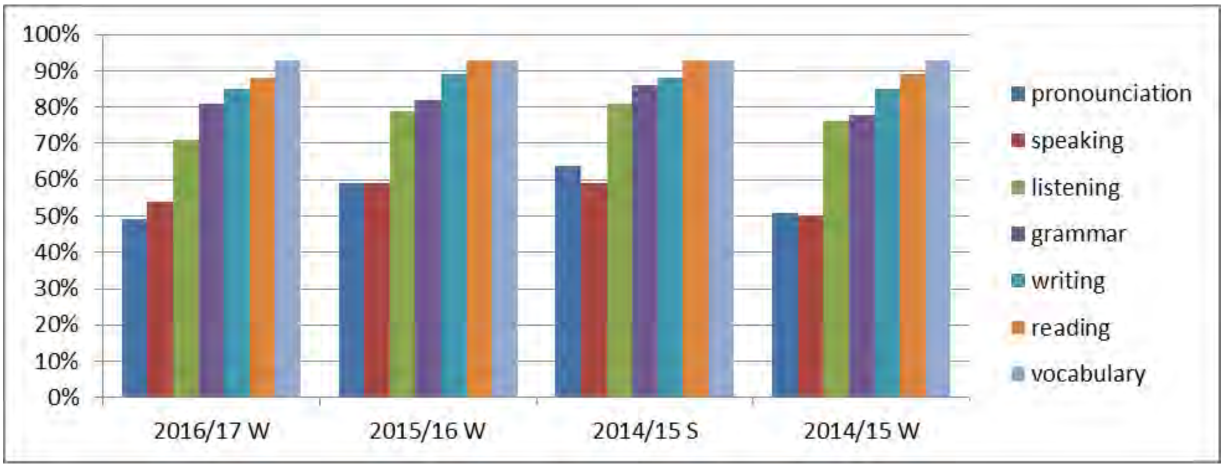

Diagram 1. The percentage of positive replies („yes”) given by students in the evaluation forms (within 4 semesters: W – winter, S-summer; 2016/17W N=113, 2015/16W N=138, 2014/15S N=69, 2014/15W N=139) on their skills increase in: pronunciation, speaking, listening, grammar, writing, reading, vocabulary.

5. The innovation introduced

The results of the evaluation questionnaires have shown evidently that the speaking and pronounciation practice component is insufficient within the e-course (see Diagram 1.), even if some of the assignments within the e-course were thought and designed to play the role of the speaking practice equivalent. Therefore, the technological progress in the area of mobile apps and their widespreading usability came up with support for filling this gap. Thus, the speech recording option was added among the other assignments within the thematic modules of the on-line course embedded on the Moodle platform (Figure 5, 6).

It is worth mentioning that prior to a new form of assessment, focus group interviews were held both among the teachers and the students. Both groups were in favour of introducing the new form of the realization of the assignment.

So far, in each e-course, the students have had the opportunity to express their views and opinions via the personalization tasks contained in two forums in each thematic unit. The forums served as warm-ups and follow-ups to the topic. They contained visual material, stimulating the learners to provide answers to the questions posed, accompanying the visual input. The tasks were intended as fluency practice and therefore, they were used to encourage students to “speak” and express their views. They turned out to be quite involving and the students eagerly fulfilled these tasks. They were given a word limit of up to 120 words. However, the students provided their answers in the written form.

Although the topics of the forums were interesting and left a lot of freedom for personal expression, the written form of the responses did not allow e-teachers to actually hear the students’ speech and their speaking skills development. They couldn’t evaluate the students’ pronunciation, word and sentence stress, intonation and thoughts organization or text cohesion. The only thing they could see or rather read, was students’ grammatical and lexical mistakes – which they were not supposed to pay much attention to because the tasks were not accuracy oriented (yet the e-teachers were welcome to provide delayed feedback if they felt it was necessary).

At the start of the summer semester 2017, a new option was taken into consideration and introduced in the English language e-courses, allowing students to enclose audio files in the forum entries instead of providing a written response (Figure 5, 6).

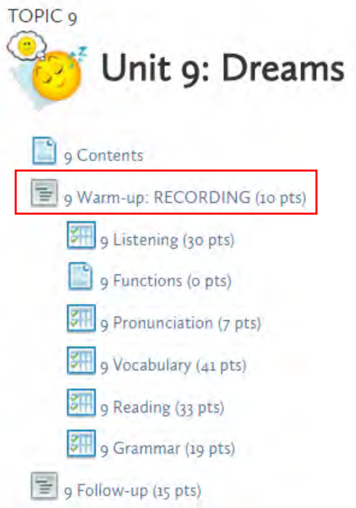

Figure 5. The example of the unit structure with the implementation of the speech recording task.

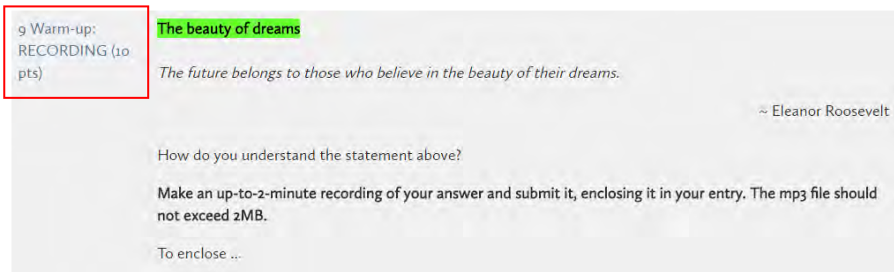

Figure 6. The example contents of the speech recording task.

The students were provided with the instruction, available on the main page of the e-course, on how to submit an audio file and add their recording to the forum entry (a Warm-up forum). The requirement was that the recording was to be not more than 2 minutes long (which indicated the maximum length and not the required length) and not “heavier” than 2MB. It could be made with any device students had at hand, including the mobile devices, on condition it was of an mp3 format.

The e-teachers, who also had their working preferences and teaching habits, were trained on how to deal with the change and how to manage and assess the contents of the mp3 files sent by students. They were also given a choice of how many tasks of the recording kind they wanted to have in their e-course (the maximum number was 10). If they felt it would be a great inconvenience to go over all the recordings submitted, they could go back to obtaining the written form of the students' response.

5.1 Very first feedback

The work is now in progress and the first feedback from individual e-teachers is returned, namely, that the change let the students have more speaking and listening practice and that it pauses no technical problems in submitting the audio files. The tangible results of the change will be available at the end of the summer semester, when both students and e-teachers will fill in a questionnaire about the application and efficiency of the innovation introduced.

As an added value, the opinions of students are considered in the area of self-assessment. When listening to their own speech recording, they were already able to make some self-assessments, correct themselves, and finally record an improved version of their spoken response.

6. Further direction

The renewed and updated evaluation forms are planned to be designed in order to check how the change introduced will have met the expectations of students and also to find out what should be modified on the basis of the replies within questionnaires obtained both from students and e-teachers.

7. Summary and conclusions

The value and the additional benefit of the language e-courses improvement is the consequent and consistent University's students and teachers' ICT skills upgrade. The student-oriented ELT methodology should be continuously taken into consideration while preparing online courses, along with the new educational and technological tools being developed. In the language courses, both stationary and online, the more speaking practice reflecting real life students get, the better users of the language they will be in everyday life. Therefore, efforts should be made to ensure the best and most efficient ways of providing opportunities for the development of students' linguistic and communicative competence.

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Aalto Online Learning - a pathway to reforming education at the Aalto University

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Keywords
Online Learning; Blended Learning; Co-Creation; Community Building

1. ABSTRACT

Why is it essential to enrich learning experiences at a university by moving online? What should a university do to reshape its offerings to better fit online learning settings? How to create communities of teachers to facilitate learning about online tech and pedagogy from peers? Who should be involved? In this paper we discuss these questions that have been addressed by the Aalto Online Learning (A!OLE) project to initiate a path for a culture shift in the Aalto University to offer significantly more online/blended learning options for our students. We discuss this from various angles, ranging from the strategic decision to invest in online learning development (motivation), to community building and mutual coaching, and finally to dissemination of best practices for producing online learning resources as university wide shared activities.

2. TRANSFORMING EDUCATION REQUIRES ACTIONS

Digitalisation is transforming higher education. Aalto University considered this a strategic challenge and launched in 2016 a 5 year project, Aalto Online Learning (A!OLE), to address it and reform its current educational culture. A!OLE project started first with nine pilot courses from all Aalto University schools and the Language Center and has up until March 2017 grown to include more than 50 pilots. The goal is to develop, explore and evaluate novel advanced technical solutions and pedagogical models for online/blended learning, often best realized as inverted/flipped classroom (see e.g. Lage et al. 2000 and Mason Shuman, Cook 2013). The key results are both new online learning resources for students, and dissemination of identified best practices and models into wider use for teachers in all Aalto schools and units to facilitate a creation of engaging online/blended courses.

We recognize that digitalization of education is not a goal *per se*. It is a means for improving quality of education and addressing challenges in the modern society, for example, facilitating access to education for a more diverse group of students, many of whom cannot regularly attend the campus for various reasons (like working elsewhere or international mobility). The increasing number of students requiring personalized and flexible learning, yet often from distance, together with limited teaching resources also raises serious challenges for scaling up educational offerings or even for maintaining their current level. At the same time the on-going massive digital transformation calls to make sharing of learning materials to be easy and rewarding.

At the same time university pedagogies are transforming from teacher-centered approaches (i.e. teaching) towards more student-centered approaches (i.e. learning). This calls for novel ways to support students in building skills for lifelong, proactive learning. Interactive, pedagogically sound digital learning resources can provide here better support compared to printed materials, or static web pages. Enriching the learning process calls for developing these engaging, interactive digital solutions to achieve true transformation of education to meet the needs of tomorrow. To reflect the first year activities and results of A!OLE, we summarize below the identified main challenges and discuss the key experiences and emerging best practices.

Our vision and goals for the next four years, and beyond are:

1. a networked community of teachers that are willing to coach each other, and also to be coached on creating online learning contents, methods and tooling.
2. in next three to four years a set of a few hundred pilots—making the annual pilot amount to be around 50—that implement and evaluate ideas iteratively into courses, both to existing ones and to newly created.
3. a core set of selected and developed platforms tightly related to themes, and where our internal and external expert network forms a strong basis for support and further development
4. online guidebooks and intensive workshops that support both using suitable pedagogical models, online platforms and tooling, and also creating of them in an iterative fashion
5. tested concepts for
    a. different educational settings to be used either out-of-the-shelf or with minimal tailoring
    b. supporting learning of teachers to be professional producers of course components for online/blended learners

3. ELEMENTS OF THE CHANGING EDUCATIONAL CULTURE

Digitalization of education is a highly complex process. An obvious, yet nontrivial step is to produce high quality online learning contents, e.g., online textbooks, presentations with audio explanations, video tutorials, animations, and interactive learning contents like simulation tools and automatically assessed exercises. Moreover, another set of challenges is introduced when transforming current practices in the teaching/learning processes (communications, team working and grading into a digital form) for online learning settings. Both areas include considerable learning curves for the university staff with a varying range of ICT skills. However, even more challenging issues remain.

Essentially we need to identify, develop and disseminate new pedagogically sound approaches within the university, such that employ digital resources and tools in an efficient and meaningful way to support learning. Traditional classroom-based education with lectures, closed labs and manual grading cannot be straightforward transformed into digital form without taking serious risks on poor pedagogical choices. We therefore need to rethink much of the pedagogical and organizational practices with the goal of combining the best sides of online learning and face-to-face sessions to create novel high quality teaching and learning processes and experiences (see McLaughlin et al. 2013, Pearson 2012, Tune, Sturek and Basile, 2013).

We aim at changing the whole educational culture in the university. For example, automating mundane tasks allows teachers to focus on student guidance instead of grading mechanical tasks. This guidance also includes selecting and facilitating digital learning resources (like intelligent tutoring systems (Strayer 2012), online video tutorials or automatically assessed exercises) which students can explore on their own or in groups. Then *in situ* face-to-face sessions and human teaching resources can be used, e.g., for orientation to the field, discussion, joint problem solving, and constructive feedback. The log data on how students use digital resources allows analysis of students' learning processes and studying practices to provide them advanced personal feedback, and earlier identification of cases (e.g. student is struggling) where teacher intervention is needed.

Building such a new educational culture is a long process and a major effort. It requires building incentives for teachers to change their existing practices, and providing adequate on-demand support functions for them. Strong support and considerably resources from university leadership are essential. However, such a culture change cannot be simply ordered "from the top". A central part of the change process is building supporting networks and activities for teachers at a grass root level. For this we have initiated a concept of an open *call for idea proposals,* where any staff member or student at the Aalto University can propose an idea related to online/blended learning and be considered for getting support in terms of design, technology or pedagogy together with funding to bring her/his idea to practice.

4. ENGAGING CO-CREATION AS A KEY FOR COMMUNITY BUILDING

The core idea for organizing A!OLE project already from the start has been to create a network - thus a community - of educational practitioners and teachers within the university. This way people are both available to coach other people but also to get coached on challenges they face when creating online educational materials, tooling and pedagogies. Indeed, collaboration via “communities of practice, multidisciplinary leadership groups and open social networks” (see Becker et al. 2017) are keys to facilitate teachers to learn from each other. Naturally coaching needs to be facilitated by *offering meaningful events* to meet others and learn what others expect and can offer. This supports bringing of learning and professional development to a collaborative framework and can empower teachers to use similar methods in their own teaching.

We have therefore organized A!OLE activities via engaging workshop style sessions and online tutoring resources. We have identified certain key themes as focus areas for these, currently including video production, virtual and augmented reality, online textbooks, automatic assessment, educational games and gamification, and finally generic flipped classroom and blended learning methods. In workshops and events we have introduced ongoing and forthcoming online learning projects. Further on, we have discussed motivations, experiences, on-line learning technologies and topics related to international collaboration.

We have recruited theme leaders to create sub communities for all these themes as an answer to the growing number of teachers directly involved within the A!OLE pilot activities (around 100 in March 2017). We have also recruited support people to help A!OLE pilots in different aspects on video production, automatic assessment tools and building interactive learning contents. Close collaboration with Aalto Learning Centre, the pedagogical training unit and Learning-IT services is also essential.

We have used these identified themes as a basis for our planning in an agile manner, thus identifying key challenges teachers have on producing online resources, and then timely providing solutions, accordingly. An example of this is providing teachers tips and methods how to present at the front of a video camera (like on postures, eye contact with the camera, composition) or enabling smart campus ideas via gamification and personalized information access. It is also important to present evidence on working pedagogical models and findings, e.g., that people concentrate better on short videos (see Guo et al., 2014). Further on, we have found out that the community building is greatly facilitated by the active use of spaces at the Aalto Learning Centre together with branding of time slots (preferably always the same space and time) for forums, workshops and studio sessions.

Events have provided to be very useful for community building and as inspiration sources. In December 2016 we organized in our new learning centre a large gala event[1] that gathered over 130 interested to join. In the gala we provided the results of A!OLE pilots via demos of online tools and materials, thus letting participants to try themselves different toolings. We had screens and poster stands gathered around themes. Further on, we employed the concept of “minute madness” and realized it as 45 second lightning talks by each of the 30 pilots of the year 2016. Figure 1 summarizes the three key event types employed by the project: annual, montly and weekly events.

[1] See https://onlinelearning.aalto.fi/2016/11/27/aole-gala-december-20th/

Figure 1: Three key event types employed for community building

5. POSITIVE, NEGATIVE AND INTERESTING ISSUES ON ONLINE LEARNING

We are building the project as a lean community-driven effort. This means in practice that we have employed workshop-style sessions to collect both emerging options and challenges related to online learning as seen by teachers and other stakeholders (like students or program directors). In this section we elaborate the findings according to PMI (plus , minus, interesting) method, where plus means positive issues, minus negative issues and finally also interesting opportunities are mentioned. We have collected these comments in various sessions either via SWOT-analyses, or via other intriguing methods (like questions on how students or teachers see the future of online learning). Table 1 shows the main results of these discussions.

Further on, the roadmap for A!OLE project includes to increasingly create measurable goals (e.g. via learning analytics) and thus build understanding of the impact of online learning options, development of funding instruments (like seed funding vs. cross school, big development projects), improving infrastructure (software, hardware and spaceware), leadership to foster transdisciplinary development and sharing educational resources and best practices, and ensuring commitment from departments for a longer time transformation of education. These, together with sensitivity and actions according to clear trends (like artificial intelligence, haptic interfaces, online & mobile as normal operations, see Adams Becker et al. 2017) in the higher education will continue to support Aalto University to offer engaging learning options for students and prepare them with skills needed by the ever-changing global society with grand challenges.

Table 1: PMI (Plus, minus and interesting) method used to categorize positive, negative and interesting issues related to online learning as emerged in our workshops

Plus	*Minus*	*Interesting*
Changing role of the teacher, teacher does not have to be just a talking head.	Education of teachers needs large-scale investments and methods to support them for the novel learning (both for online and active learning spaces).	Teachers and students get to learn in new collaborative, community-building ways. Redefinition of learning spaces is highly needed to enable interactive, learning-intensive workshop sessions.
Students are in any case looking for information online (Wikipedia, Youtube, etc.). Bring your own device (BYOD) culture is rapidly growing.	The amount of information — both correct and false information— is rapidly growing. Not all students have good enough, own computers and pads to participate teaching online.	More responsibility can be given to students on leading their learning. Further on, as we can evidence nature and sky contain huge amounts of information: can we learn from the nature to make very natural interfaces even for big data by using augmented and virtual reality tech?
Students can access learning anywhere, anytime.	The option to work 24/7 can potentially introduce stress.	Learning can happen in surprising new places, and in practice any places can be augmented for seamless learning.
The emerge of new technologies enable to put more effort on face to face sessions.	Teachers have raised the issues about non-working tech in classrooms (like a crashed projector) and online (like a relevant link not reachable). Teachers have too little personal experience in participating teaching that make use of online tools.	Augmented reality and virtual reality provide substantially different ways to learn both in situ, and also in 360 degrees, controlled environments.

5. CALL FOR IDEA PROPOSALS AS A GRASSROOT ACTIVITY

We have called now idea proposals on online learning in three rounds (April 2016, December 2016 and April 2017) from all people at the Aalto University, thus including faculty, program directors, researchers, staff and students. Via discussions and involvement of stakeholders we have selected the best ideas and invited people behind them to join the network of teachers in A!OLE. The network provides support on design, technology and pedagogy for teachers to realize the proposed idea in practice. After the evaluation of the ideas we have often discussed on funding to allow for full concentration on developing the idea to reality.

This may include funding in two phases. Seed funding will allow exploring and identifying appropriate tools, technologies, existing online resources and pedagogical principles on which to build a new A!OLE pilot. A part of seed funded phase is also to discover options for collaboration with existing A!OLE pilots. Further on, the seed funding is meant for preparing a better informed proposal in terms of the schedule and budget to support implementing the pilot idea. After this phase, augmented proposals need still to be separately accepted, but with a high potential for acceptance.

In Table 2 we summarize the main fourteen questions (Q1-Q14) in our call for idea proposals to illustrate the setting. The key idea is to encourage applications to consider and give arguments for the change in the learning process that the proposals aims to implement. Additional questions concern the ideas how the implementation would be carried out.

Table 2: Summarization of the main fourteen questions in our call for idea proposals.

	Question
Q1	*Please describe the current situation of the teaching related to the pilot (course, types of teaching, teaching material and which part of it is online material). Is there an identified problem in the current state of affairs that you are seeking to solve with the help of the pilot?*
Q2	*Please explain the goal state - what will the teaching and learning at the course be when the pilot is finished? What are the essential changes to the current state of affairs? Which part of the current teaching / learning will move online or will be novel online activity? How the realisation of the pilot will improve learning and/or activities by the teacher/student?*
Q3	*What kinds of activities for learning and teaching are you planning to develop in the pilot? For instance: Video production, Automatic assessment of exercices, Serious games, gamification, Virtual reality, Augmented reality, Online textbooks, Peer review*
Q4	*How are you planning to evaluate the impact of the pilot for learning and teaching within the course?*
Q5	*How could students participate in the pilot?*
Q6	*How can the implementation of the idea change the online learning culture of the associated school/department/unit in the years to come?*
Q7	*Which of your collaboration partners can support realization of the idea or take advantage of it?*
Q8	*Are you planning to open the course online resources after the pilot or later on as MOOC to all interested?*
Q9	*Who will participate the realization of the idea and in which roles?*

Q10 What kind of technical, design or pedagogical support (or something else) will you need to realize the idea?

Q11 What kind of findings you have (or how are you planning to research) on tooling or materials that you could use for the pilot?

Q12 Please explain which technologies (like online learning platforms, online-tooling, software) are you planning to use in the pilot. Please argue why exactly those.

Q13 How your pilot can be linked our existing pilots? With which pilots are you planning to collaborate with?

Q14 Are you aware of prototypes (e.g. online resources) that can give more information about the proposed idea and its goals?

These questions have greatly supported us to select those ideas that best look for improvement of learning. For instance, comparing of answers to Q1 and Q2 should give an idea of the targeted delta of the idea proposal, similarly as the answers to Q4 provides insight on plans to evaluate the pilot. Q10 through Q12, and to some extent also Q14 are very useful in preparing our roadmap for selecting ideal online tooling and planning according support while Q6 and Q13 are all about community-building.

6. ONLINE VIDEOS AND NEW FRONTIERS

We have evidenced different forms of video production to be most prominently required by teachers. For this we have iteratively developed a model for helping teachers to gain skills and to aid them in the production. Our skill-building workshops have ranged from video script writing through presentation skills and use of a tele prompter use to animation creation and video sharing. We have also provided hands-on sessions on selecting appropriate licenses for works and informing about copyright issues. In all of the activities we have recorded the number of participants, and made decisions on next workshops and themes, accordingly.

Currently this has led us to focus especially on video presentation skills (like voice, postures and prompter use) and script writing as they gather most interest. Building of these skills are not well supported by existing units at the university, unlike for instance video sharing and copyright/license issues. Figure 2 gives an impression of the hands-on mentality at our workshops, showing how participants are using a tele prompter they have themselves built in the workshop. As a result of the enthusiasm and discussions on actual needs we bought a professional tele prompter from the market. However, building the tele prompter ourselves greatly supported understanding of what in fact is needed from a professional tool by our pilots.

Figure 2: Participants using a tele prompter they themselves
built in a themed workshop on video production.

Emerging forms of educational videos that we have evidenced in our development and benchmarking activities include, but are not limited to, the following six kinds:

1. A talking head with slides, typically both shown at the same time or in sequence. Voice is used to explain the slides
2. A slide deck with a teacher explaining the slides with her/his voice
3. Animations, where various graphs or human-imitating characters are used to explain the study subject
4. Short plays where acting exemplifies some situation for learning (like for language learning, or for business case presentations)
5. Vlogs, where a teacher discusses relevant issues in a more natural-like settings (like explains theory, or gives task assignments or feedback on report/exercise submissions by students)
6. A tablet used as a whiteboard (like for explaining mathematical formulas)

The rapid movement to online videos has disrupted very fast traditional fields ranging from television production through cinema and music to videos supporting learning. Similar disruption is now already ongoing—potentially even faster than with videos—via the new frontiers of augmented and virtual reality together with games.

The virtualization ideas range from spatially mediated experiences via an augmented campus in order to learn languages to virtual realities made possible by 360 photo/video capture or custom-designed virtual space designs. At the same time students are also supported to get familiar with services offered by the university. Searching for information in situ at augmented and gamified university spaces—triggered by both places themselves but also by previously completed tasks—can enable students to get into rich contexts to support their learning.

7. CONCLUSIONS

In this paper we discussed our plans and activities to develop online and blended learning settings at the Aalto University to better target the both on-going massive digitalization transformation and improvement of learning. We reported about our goals to have a networked, active community of skilled teachers that are equipped with state-of-the-art tooling and platforms, and research-based evidence on working pedagogical models ranging from classrooms through online videos to augmented/virtual reality settings. In our vision this is best supported by gathering of emerging ideas as a grassroot activity and bringing people behind the ideas actively to form teams around our selected themes.

This way we wish to have in next few years hundreds of pilot projects from our all different schools, thus making the strategy implementation a rather unique, and truly transdisciplinary and interdisciplinary approach. A core part of the community-building are both online wikis and guidebook coupled with intensive, themed workshops that target skill development and joint creativity. As we reported, we build and evaluate workflows and concepts (like for educational video production) in an iterative fashion.

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Malmi has been leading the national Center of Excellence in Education at Helsinki University of Technology in 2001-2006. He has chaired Koli Calling, international conference in computing education research in 2004 and 2008, and he is a frequent PC member in several other computing education research conferences. He is a member of the editorial board in IEEE Transactions of Learning Technologies, ACM Inroads and Informatics in Education. He is also a board member of SEFI Engineering Education Research working group and Nordic Network in Engineering Education. He has been leading several international doctoral consortia in computing education research and he has continuous interest in improving research training in computing and engineering education research. Contact: Lauri.Malmi@aalto.fi.

WHAT IS "FLEXIBLE AND PERSONALIZED EDUCATION" ANYWAY?

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flexible and personalized education, innovation in higher education, vision and practice

1. SUMMARY / ABSTRACT

What is "flexible and personalized education" anyway?
The current state in Dutch Higher Education

An analysis of strategic plans of 40 institutions of higher education in the Netherlands shows an overlap in ambition: a search for more flexible and personalized education. But what does that look like, costumized education? And how would or should that prepare students for a career in a rapidly changing world? SURF, the collaborative ICT organisation for Dutch education and research, spoke to a large group of innovators that try to translate concepts of flexible and personalized education to classroom practices. We spoke to people who are changing the way they offer their courses, and explore, in the classroom, what works and what does not. We also spoke with visionaries who think about what we need to change to prepare students for the future. We asked them what they see as flexible and personalized education, why it is needed, what we have to change and offer to enable it, what organisational bounderies we encounter, what already is happening, and what their vision of the future is. We had them meet up and share their visions and inspire each other. We included international publications about the subject in the discussion. We looked where vision and practice seemed to connect and where it collided. During EADTU Christien Bok, program manager of SURF Technology Enhanced Education, will present the current state of flexible and personalized education in Dutch higher education, and how ICT can contribute to shape

2. WHAT IS "FLEXIBLE AND PERSONALIZED EDUCATION" ANYWAY?

1. INTRODUCTION

A large number of universities, technical colleges and university medical centres in the Netherlands harbour the ambition of offering personal and flexible education. Placing the student at the core of their teaching seems a better option than placing the curriculum at the core. Not every institution is at the same stage in achieving this ambition. In practice, it seems that it is not yet very clear what exactly personal education is, and when it provides an improvement in quality.

The terms personal and flexible are defined and interpreted in diverse ways by different institutions. In this white paper, SURF is setting out to define and describe the topic of "flexible and personal education". We also refer to this as "customised education". The goal of this is to provide the higher education sector with a grasp of the different options and the issues they bring with them. We will examine questions like: Why is customised education needed? What might customised education look like, and what do institutions need to take into consideration when setting it up? The white paper is intended for educational developers, policymakers and lecturers who are involved in shaping customised education.

In preparing this white paper, we have carried out a large number of interviews and held discussions with representatives from Dutch technical colleges, universities and student associations. We have gratefully made use of their insights and practical examples. The different examples allow institutions to learn from each other and show the full bandwidth of the subject. The title of this white paper is *Customised education in 2016*, because in the discussions we held, we were far from covering all the points of interest on the agenda, and because new experiments, developments and research in the next few years will undoubtedly rapidly provide new insights.

Based on our discussions we distinguish between five educational dimensions for customised education that could be helpful in developing your own vision. The crux here is that institutions and programmes define, based of their own vision on education, which dimensions they want to emphasise to a greater of lesser extent when implementing customised education. Customised education looks different not only for each student, but also for each university, college and lecturer.

Education means working with people. ICT can never replace people, but it offers lecturers options to allow them to implement customised education. Digital assessment makes it possible to hold exams more flexibly, and offers the opportunity of testing learning targets that cannot be tested in a written exam. Analyses of tests give lecturers insight into the quality of the tests and test items, which improves the reliability of the tests and the ability of the lecturer to set tests. The use of study data provides insight into personal progress with study, meaning the students can work in a more targeted way on their weak points. Students are also asking via their representatives1 for more digitalisation of teaching. SURF helps institutions by providing ICT services that enable innovation in education and customised education. Over the next few years, we will be intensifying our research, in collaboration with the institutions, into customised education and the ICT services that are required for this.

2. WHY CUSTOMISED EDUCATION?

The knowledge economy is placing greater and greater demands on people. Mid-level jobs are disappearing, and the need for higher education is growing. A one-size-fits-all approach cannot deliver this. Education must make space for more people with different backgrounds, talents and needs. This in turn requires differentiation.

Jobs are mutating or disappearing at a rapid rate. Lifelong learning is necessary. To remain accessible and attractive to people at each stage of their (professional) lives, education must take account of differences in goals and circumstances.

In this chapter we examine the importance of customised education from the perspective of the student, the lecturer, the job market and the educational establishment.

2.1 The student

Young people have greater choice in every area of their lives than they did in the past. Smartphones and tablets have become an extension of themselves; boundaries between learning, living and working are blurring. They also expect freedom of choice in education, and want to be able to use ICT applications. Beside this, the student population continues to become more diverse; students with a variety of backgrounds, levels of knowledge and different learning needs benefit from a freedom of choice. Students also need the flexibility to be able to combine work and life with an education.

Different talents, backgrounds, prior knowledge

Einstein supposedly once said of the education system: "Everybody is a genius. But if you judge a fish by its ability to climb a tree, it will live its whole life believing it is stupid." Students have different talents, backgrounds and prior knowledge. An education will not always connect with or take into account some very specific combinations of talents, knowledge, skills and interests on the part of students.

Speeding up and slowing down

Whereas in the past students could study for as long as they wanted, currently students are tied to a fixed number of study years. But for many students, their time as a student is also an important time in their development. Students want to travel or do management work or volunteer work. Registration per academic year can be restrictive.

Studying at multiple institutions

More and more students also want to take subjects outside their own course of study or institution. A minor or optional subject in another faculty or educational establishment provides a broader

[1] ISO, LSVb (spring 2016), Measures to make education more flexible. Paper on creating flexibility in higher education from ISP and LSVb

perspective of the subject. Of course with the advent of MOOCs, SPOCs[2] and other online courses and teaching materials, students can choose from a vast selection, including from other institutions.

2.2 The lecturer

Teachers have – just like students – different abilities and preferences. Just as students have different learning styles, they have different teaching skills. In the classroom, a lecturer who likes conventional teaching, and who prefers to use their contact hours this way, is better than someone who wants to experiment with innovative forms of education.

When students have a lot more freedom of choice in how they complete their studies, then lecturers assume a new role. They supervise the learning and selection process as coaches or mentors of the students, provide context and content, and sometimes also act as online moderators. This new role demands different teaching methods and different abilities. Above all, lecturers are professionals who are expert in their subjects, and must remain so. By creating teams made up of lecturers, ICT support staff and experts in education, each team member can contribute what they are good at. Some lecturers are pioneers and contribute innovation, while other lecturers contribute mainly their domain content.

Teachers also have a heavy workload to deal with, even without any added innovative strategies. In addition, especially in universities, lecturers are judged more on their research results than on their teaching abilities. To stimulate educational innovation and to motivate university lecturers better, there is a need for an educational career path, with an appropriate HR policy. That also needs to be aligned with the new role of lecturers as coaches and mentors.

2.3 The job market

Careers, jobs and tasks are changing ever faster. Thanks to technological advances such as digitalisation and increased use of robots, some professions and careers are disappearing and new ones are being created. The content of careers is also changing. To resolve complex problems such as the environment, ageing populations and rising health costs, creative and adaptable knowledge workers are needed who can work together across disciplines. Companies and organisations are probably looking more for flexible and adaptable employees than for domain experts. They need highly educated employees who are able to deal with change, and who know how to identify and fill in gaps in their knowledge. Higher education needs to prepare students for this and to teach them how to handle it.

Up-to-date knowledge
Employers expect graduates to enter the job market with up-to-date knowledge. That requires the institutions to keep their curricula constantly up-to-date, and to continue to keep up with new developments. They also need to teach their students that personal development does not stop when you get your certificate. They need to ensure that students are able to prepare themselves for the following stages in their career and are able to manage their own learning process.

Skills as well as knowledge
As well as factual expertise, employers are increasingly looking for soft skills such as creativity, critical thinking, problem solving ability, communication and working in a team. Leadership, self-awareness and providing feedback are also becoming more and more important. Within the current curricula these skills often receive little attention, and students have less time to acquire these skills alongside their studies, due to the shorter time spent studying. More attention should be given to this in courses of study.

2.4 Educational institutions

Institutions are faced with the challenge of making education more effective while at the same time maintaining the quality of education. Rising student numbers, less funding per student, low yields and high drop-out rates are forcing institutions to make teaching more efficient and more effective. Institutions need to shape their teaching to fit the demands of students and the job market.

[2] MOOC: Massive Open Online Course, SPOC: Small Private Online Course

Study switchers and drop-outs
A substantial proportion of first-year students change their subject or drop out. More freedom of choice within the curriculum offers students the option of changing direction during their education. Matching, information and insight into the professional word also remain crucial.

Part-time education
In 2014 the advisory committee on flexible higher education for employees noted that "results in the Netherlands in the area of lifelong learning [lag behind] the ambitions, while the urgency of this keeps on growing. In this area, the Netherlands is trailing well behind its own ambitions as a knowledge economy."[3] With truly flexible education programmes and more opportunity for students to follow their own path at their own speed, taking their individual circumstances into account, the distinction between full-time, part-time and work-study education should disappear.

3. WHAT IS CUSTOMISED EDUCATION?

Customised education always means *personal* and *flexible* education. Personal education is not based on a fixed educational programme, but is aligned to the wishes and preferences of the student. Personalised education enables students to define their own learning paths. Flexible education offers students freedom of choice. If students are able to pursue their education when and where they want, more flexibility becomes possible and more freedom of choice can be provided. That makes learning at your own speed and on your own schedule easier.

Customised education can take a number of different forms, which can always be defined in five dimensions from the student's perspective. The selected mix of dimensions, along with the breadth of each dimension, leads to customised education for each institution. Two dimensions relate to *what* the students learn, three to *how* they learn:

What the students learn:

- freedom of choice of content
- fitting with their background

How the students learn:

- in their own time and place and at their own speed
- at their own level
- in their own way

In this chapter we briefly describe these five dimensions.

3.1 Freedom of choice of content

Freedom of choice of content enables students to match their education to their own ambitions, interests, talents and abilities. It also enables them to pursue parts of their education at a number of different institutions. By creating unique combinations, they can differentiate themselves in the job market.

Freedom of choice can apply at a number of levels. For example, lecturers can offer their students freedom of choice within a course. Within a course of study, students can be given the choice of taking or not taking specific courses, often with room for elective courses and activities. And finally, students can choose the educational institutions where they want to pursue their education.

3.2 Fitting with the background

By taking account of the (prior) knowledge, skills and experience of each student, institutions can do justice to each individual. Particularly for students with work experience who want to develop themselves further, that can be very attractive.

[3] Flexible higher education for adults Consultative report dated 12 March 2014

Universities and programmes can offer students exemptions and adapted programmes, based on their experience and prior knowledge. Programmes can also continuously adapt their content, presentation and feedback to the level of the students. Learning analytics offer ways to customise this adaptation. By analysing students' learning data, students and lecturers can gain insight into learning results and learning behaviour, enabling tailored support for students.

3.3 Own time, place and speed

Institutions can offer students the opportunity to study in their own time and at their own place and speed. In this way institutions accommodate individual circumstances in the lives of their students. That makes it easier for students to combine their education with work, family, care, etc. The availability of online courses makes it possible to take courses at other institutions, including abroad.

Learning at their own speed allows students to speed up or slow down. If they have learned all the material in three weeks, then they can sit the exam after three weeks. If instead they need twenty weeks, that is not a problem. In this way, institutions can adapt to the specific talents of exceptional students. Adaptive teaching makes learning at the student's own speed possible.

3.4 At their own level

Presently most education is offered at a single level. However, this sort of education may be too difficult for some students and too easy for others. By stretching excellent students further, they are kept motivated. In addition, they can differentiate themselves for potential employers. Students who have problems with specific parts of a course should, where possible within the scope of their final qualification, be able to take some subjects at a lower level.

3.5 In their own way

Students can work more successfully if they have the opportunity to learn in the way that suits them best. Some prefer lectures or seminars on the campus, while others would rather learn at home with a book or use tutorial videos or games. Some students have a preference for problem-based learning, others really dislike it. Freedom of choice to learn in various ways enables students to choose from among the learning methods, learning materials and support that suits them best. Furthermore, the teaching methods always help to guide the approach and the way in which education is provided. This determines the degree of freedom of choice.

4. WHAT IS ALREADY HAPPENING?

In the Netherlands, there is already plenty of experimentation going on with customised education. Some forms of customisation, such as freedom of choice at the master's level or development of online education, are already the norm in many institutions. Institutions are also carrying out pilots to better define the boundaries of customised education. A number of examples of how institutions have made choices to implement one or more dimensions of customised education to a greater or lesser degree are described below.

4.1 Freedom of choice

At many educational institutions students can take a minor subject elsewhere, sometimes also outside their own subject area. University colleges and liberal arts and sciences colleges offer a bachelor's programme with a lot of room for elective content. That also applies for many master's courses. At the University of Utrecht, all bachelor students can define a quarter of their curriculum themselves.[4]

Individual definition of a full course of study also occurs, but on a small scale. An example is the contract education programme at the Erasmus Academy. Part-time students here can select their own courses, and on the basis of these, create their own master's degree. Another example is the bachelor's in ICT from Fontys, where students can choose from seven study paths after the first year.

[4] http://www.uu.nl/bachelors/veel-keuzeruimte

4.2 Background

Various educational institutions take account of prior knowledge, experience or skills. Higher vocational training institutions participating in pilot projects with work-study or part-time education assess case by case whether students should follow a standard course of study or qualify for a customised course of study because they have already achieved specific learning goals.

The part-time course of study in Management, Economics and Law at HZ University of Applied Sciences, started in September 2016 with education based on learning outcomes. Students can bring in projects from their job and qualify for study points if they demonstrate that they have already achieved certain learning outcomes. At the Windesheim University of Applied Sciences, part-time students in educational programmes (secondary and primary lecturer training) are eligible for exemptions base on previously acquired knowledge and skills.

The Utrecht University of Applied Sciences offers testing independent of the manner of learning: students can sit a test once they have mastered the course material, without being required to attend the classes for the course. At the Amsterdam University of Applied Sciences, study time can be reduced on the basis of skills acquired previously.

4.3 Time, place and speed

Windesheim University of Applied Sciences offers part-time students in educational programmes (secondary and primary lecturer training) the option of distance learning to develop theoretical knowledge. This is, however, done at a defined speed, with a tight study timetable and hard deadlines.

Despite the broad availability of MOOCs, their penetration into regular education is still very limited Students who want to be credited or get an exemption for a successfully completed MOOC sometimes find it is a lengthy struggle. An exception to this is the programme "Wageningen X", in which Wageningen University is working towards integrating online and offline study options, including MOOCs. There are now two fully recognised master's courses available: Nutritional Epidemiology & Public Health and Plant Breeding. Starting with the 2016-2017 academic year, students at Wageningen University will be able to collect study points for MOOCs from their own university. These courses can be taken completely online, and students sit the exam at the university.

In part-time courses the students can postpone their courses. Speeding up is also possible, for example in the medical faculty of the University of Leiden. Students can use the freedom of choice in their transition year, after their basic medical training, to begin courses that fit with their specialisation. The result of this can be that students complete their specialisation six months earlier.

4.4 Level

Many institutions offer honours programmes for students who want to and can do more. These programmes have to some extent been developed as part of the Sirius Programme[5], which since 2008 has enabled universities to challenge students who are performing well to dig deeper.

In the honours programme at HZ University of Applied Sciences, the students add an extra 420 hours to their studies in one academic year. The Utrecht University of Applied Sciences offers honours courses in all subjects, with both broader and deeper content. Around 6% of students sign up for this. At the Hague University of Applied Sciences (at the TU Delft campus), students in scientific subjects can choose between the university variant or the TU Delft variant. In the latter case, they can move directly from their bachelor's studies into a master's programme at TU Delft, without any transition programme.

Other institutions, like the University of Leiden and Maastricht University, offer online refresher courses for students, for example to improve their maths skills so that they can keep up with the bachelor's course of their choice.

The University of Amsterdam allows psychology students to do a formative test each week, with the help of the SPSS statistics programme. Through the test results, the students receive targeted

[5] https://www.siriusprogramma.nl/instellingen

feedback about their weak spots. "This way, it is almost impossible not to pass the course," says one of the students.

5. SCENARIOS FOR THE FUTURE

An institution that wants to implement customised education not only has a choice of different dimensions, such as freedom of choice in content or freedom of time and place. For each dimension, an institution can choose the bandwidth that fits with its motivation for creating education that is more customised. In this chapter, we explore what the selection of the maximum variant might look like. As to the question of whether the maximum variant is desirable for improving the quality of education: we examine this in more detail in Chapter 6.

5.1 Freedom of choice

Full freedom of choice within an institution could mean that the institution no longer offers any programmes, but rather courses from which students construct their own educational programme. Full freedom of choice in education by all institutions could mean that students no longer register with a specific institution, but only for one or more educational components. That requires unbundling teaching, testing and services. Students can then pursue their education both at home and abroad, face-to-face, blended or online.

Independent accreditation bodies decide when a student has earned a degree. That is then by definition no longer a diploma from an individual educational establishment. The diploma will state for each component which institution provided the course(s). In this context, the development of micro-credentials becomes important. Micro-credentials, for example with the aid of digital badges, are a form of recognition of skills that students can earn and can use prove their growing abilities.

5.2 Background

If we want to adapt education fully to reflect the prior knowledge and experience of students, the ultimate consequence is that all diplomas are detached from any fixed curriculum. The link between study points and nominal study hours is cut; instead, education is defined in terms of learning outcomes. The outcomes state what a student knows and is able to do on completion of a learning process, without defining a specific teaching path. Students can take exams at any time, whether or not they have followed a teaching unit.

At the start of their studies, students can take a test to rate them against the final level to be reached of the course to be followed. Based on the result, the student can choose where to acquire the missing knowledge: at an institution or in the work environment. Exams can be taken at any time, and as often as the student wants. Students pay separately for attending the courses and taking the exams.

5.3 Time, place and speed

Full freedom of time, place and speed in education implies that the full curriculum is also offered online. Students then no longer have an obligation to attend, but instead an obligation to deliver results. Students have (online) study support available 24/7. Students can make appointments with lecturers for times that suit them both. Students have the teaching materials available online. And they can take a test wherever it suits them: at home, at the institution or at a regional test centre.

Studying at your own speed means that there is no longer any nominal study duration. Students can take two years to get a bachelor's degree, or they can take six. Registering for a course means signing a contract with an institution that helps the student reach the end goal, at their own speed.

5.4 Own level and own way

For good matching to the level of the students, it is necessary to define a clear baseline for all courses at the middle vocational, upper vocational and university levels. Students can then take any course at any level they want. Their diploma will show the highest level they achieved. For all courses, educational establishments will organise extra challenges for the students who ask for them. Those can be honours courses, but also customised approaches per course. A student does not need to achieve a specific diploma level; a combination is also possible.

Studying in your own way implies that, for each course, students are able to choose from different methods of teaching, different kinds of teaching materials, and different forms of support.

6. ISSUES

Customised education is not a goal in its own right; it can equip students better for their future. To define the bandwidth of each dimension of customised education that best suits an institution, the institution needs to make choices. The scenarios in Chapter 5 are extensive. To determine whether an institution wants to opt for an extensive variant or a less extensive variant for each of the different dimensions, questions need to be asked about the desirability and feasibility of the outlined options, and about the necessary (legal) framework. In this chapter we examine a number of issues.

6.1 Legal framework

The Dutch *Wet op het hoger onderwijs* (WHS) [Higher Education Act] places limits on the freedom of choice. This act enshrines the principle that a formal education needs to be consistent and coherent. All study units must combine to achieve the final objectives of the course of study. In addition, the WHS states that the core of the curriculum must be provided by the institution that issues the diploma. This restricts the freedom to combine educational components from different institutions.

Students in higher education are given an "explicit right" to continue with their best subjects at a higher level. For example, students at a vocational school with a talent for English can take this subject at a more academic level. This was stated by Secretary of State Sander Dekker in a letter to the Second Chamber. Dekker: "Not every child fits exactly into one of the slots of the different types of school. At present, it is too often your worst subject that decides how good you are allowed to be in your best subject. This is demotivating for students and a waste of talent." In higher education this is not yet the case.

The Dutch Social Economic Council (SER) states that a clearly discernible difference is necessary between higher vocational education and academic education. This is necessary both for the recognition of courses of study and for the link between education and the job market. However, the Council believes that this difference should not be allowed to create a barrier to collaboration, coordination and transfer between vocational and academic education.

Any experiments that represent an exception to the statutory requirements normally require a General Administrative Measure arising from a political decision process. This generally hampers the launch of innovations..

6.2 Sense and nonsense of freedom of choice

Freedom of choice in creating the curriculum raises a number of questions. What is the quality of a self-constructed curriculum? How do you guarantee its coherence, and how do you define the objectives? Institutions generally opt for a limited form of freedom of choice. In doing so, they seek a balance between the degree of freedom of choice that students can cope with, a coherent curriculum and fixed objectives.

Structured freedom

Not everybody wants freedom of choice. A fixed programme can also be a valid form of customised education. However, freedom of choice also demands structure – for example, a structure that provides room and support to students who do not yet really know what they want, as well as students who know exactly what they want, within the scope of their wishes and circumstances. How much freedom a student can handle depends on the person concerned and their age. Generally speaking, 17 and 18 year olds need more direction and guidance than a 22 year old. Research by the Amsterdam University of Applied Sciences shows that students mainly need guidance and structure in their first 18 months. After that, they want more space, but without being completely left to their own devices.

Guaranteeing professional skills

Legal professions such as judge or lawyer, or controlled professions such as doctor or registered psychologist, require certain defined levels of knowledge in order to ensure the ability to practise. In these courses of study it is not easy to offer freedom of choice for the content of the curriculum. It would, however, be possible to take some courses at another institution.

Examinations
If diplomas are completely detached from the educational curriculum, the question arises whether an educational institution is the most suitable party to set the exams. The exams could then probably be better set by independent examination boards. However, the question is whether testing and setting exams are indissolubly bound to teaching.

6.3 Other points for discussion

Preserving the educational community
Teaching is more than knowledge transfer. The interaction between students and lecturers is a crucial part of education. Studying at an institution means being part of an educational community. If students are able to study totally in their own time and at their own place, this interaction is at risk. There are, of course, ever more options for online interaction between students and lecturers, but education is a relationship, and face-to-face interaction remains important for the discussion of crucial matters and sharing of (complex) knowledge.

Different speeds without detachment
The big question with speed differentiation is how the institution can organise the teaching. This includes interactions with fellow students and monitoring tasks and assignments. Teachability is also a contentious issue. In addition, there is the question of whether the lack of a deadline will kill motivation to complete a course.

The freedom associated with different speeds is not always a benefit. International research has shown that a high level of choice of speed leads to dropouts. Some students specifically need a strict framework. For these reasons, the Erasmus University Rotterdam offers more structure than previously in the part-time Law course of study: every Friday afternoon there is a lecture. For this reason, the Open University and Windesheim University of Applied Sciences have restored more structure in part-time courses of study. Working with fixed groups led to a spectacular rise in the number of completed diplomas at the Open University. The National Student Survey also shows that it has a positive effect on student satisfaction.

Do differentiated levels leads to dumbing down?
The question is whether equivalent courses can actually be organised at three levels (middle vocational, higher vocational and university) for all courses. This demands a lot of mutual coordination, which may come at the cost of the quality of education. The value of a differentiated diploma is questionable if crucial elements are achieved at a lower level. Another question is whether the job market can assess the value of a scaled down diploma when several different levels are involved.

Is it feasible?
Customised education demands choices: choices of the dimensions where an institution provides customised learning, and choices as to how far it should go. When assessing potential changes to education, the following criteria may be useful:

- Does the change lead to the desired change (students who are better prepared for the job market and better equipped for lifelong learning)?
- Is the change feasible in terms of studying?
- Is the change feasible in terms of teaching?
- Is the change feasible in terms of organisation?
- Is the change affordable?

The redesign of education costs time and therefore money. Experiments require a long-term effort and investments that do not always deliver the expected results. Differentiated education, which therefore many also be smaller scale, is also likely to be more expensive, with no additional funding to cover it. The WHW has stipulated that educational institutions may not ask students for additional contributions over and above their fees. The only exceptions are the University Colleges. If they have been designated as small-scale and intensive educational institutions by the NVAO, then they can ask for higher fees.

In the Ministry's experiments with voucher financing, the effects of other forms of financing are being studied, such as payment per module. Another experiment is that of the University of Amsterdam/Amsterdam University of Applied Sciences. These institutions are carrying out a pilot in the 2016-2017 academic year with one thousand students who are not paying annual fees, but instead are paying per course.[6] This can be financially beneficial for part-time students and for full-time students who also have to work a lot alongside their studies. The question is, of course, how financing affects the educational institutions.

7. SUPPORTING CUSTOMISED EDUCATION WITH ICT

In this chapter we offer a number of examples of how ICT can play a role in shaping customised education. The question of how ICT can enable customised education was addressed by the authors of the SURFnet trend report. We summarise their answers below.

7.1 Virtual reality

Using virtual reality you can construct the entire learning environment for a student. By using simulations in VR, students are less tied to time and place, and can experience important events, exotic locations or future work environments without leaving the teaching location or the college lecture hall. Students can decide how, where and when they use it as part of their own learning process, provided that the education/institution offers high quality content. A student can therefore influence their own learning process. Although a virtual environment can be experienced jointly with others, a virtual reality experience is essentially individual. It offers options to adjust the environment to the person, both in terms of level and of the way in which information is presented. Content can therefore be personalised.

7.2 Serious gaming

Serious gaming adds value particularly in learning situations where it is important to experience for yourself the effects of your actions. But it can also contribute to changing attitudes and reflection. Games can also be used to good effect for skill training. The use of (virtual) games/simulations for skill training offers logistical benefits: students can practice in situations that would cost a great deal of time and money in the "real" world. Serious gaming, just like other forms of e-learning, can be used individually, where and when you want. The game elements here are a bonus that motivates students to achieve their goals. Another possibility is to differentiate within the game using roles. This means students can be assigned a role within a team that suits them, or indeed a role that does not suit them so well, so that they can practice it.

7.3 The virtual classroom

It is often difficult to bring students, lecturers and (online) sources together, while direct interaction is indeed important. A virtual classroom can offer a solution. In a virtual classroom, students from different countries can follow the same lesson together, and learn about each other's cultures. The power of a virtual classroom lies in its direct interaction and the group dynamic it generates. In a virtual classroom, students work in groups. Learning to collaborate is one of the skills required for the 21st century. Here students learn that other people have other cultures and a different way of solving problems and thinking. This helps to create your own range of learning and problem-solving strategies.

7.4 Internet of things

The IoT offers wholly new and cost-effective methods of data collection. These methods can be applied to collecting data about students to support both the student and the lecturer. On campus, sensors and smart devices can be used to organise educational logistics. Managing the occupancy of teaching rooms is one example. Using data about the attendance, activities and study needs of students, you can create dynamic learning hot-spots that stimulate interaction between students. The IoT can enrich student analytics in many ways. An Internet of Everything can offer a learning experience that is much more authentic and personal than is currently possible. Reflection is based on both real data and on data enriched by the environment, and is embedded in an authentic learning environment with physical interaction options.

[6] http://www.folia.nl/actueel/98236/uva-en-hva-proeftuin-voor-collegegeld-betalen-per-studiepunt

7.5 Digital testing and learning analytics

Each student leaves a digital trace from the moment they seek out the website of the educational institution until the time they are registered as an alumnus. Link all the systems together and you gain insight into students' learning behaviour, the quality and effectiveness of the teaching. Learning analytics allows targeted feedback to students and lecturers about the progress of studies, and provides insight into how the material is being mastered. Learning analytics can also provide insight into the quality of the (online) teaching materials which can then be improved as a result. By analysing the test data from formative testing, students and lecturers rapidly receive insights into which parts of the subject matter the student has absorbed. In addition, the lecturers can see which exercises and sections of their teaching could be improved. Digital testing combined with learning analytics make it possible to integrate exercises in the student's learning and development process. Students get feedback on their development, success and any stumbling blocks. And the lecturer can also form a view: he/she sees not only the results, but also the students' efforts. Based on this, he/she can offer them customised work during a seminar or a personal meeting.

7.6 Adaptive learning environment

Based on current information about the learning process and their progress, a student may choose a further learning activity and the correct learning content for a learning path. There is a constant action and reaction, supervision, assistance and reflection back and forth between the student, the lecturer, supervisor and workplace. Every interaction generates data (analytics) that form the basis for a student profile. In an adaptive learning environment it is possible to give just-in-time information. Based on the data analysis we can provide digital learning content (for example digital tests) just-in-time for a student. We can also construct non-linear learning paths. We can render material adaptive by chopping up (large) blocks of teaching material into small chunks. This way we can vary the learning path in order to match the level,speed, interest and other characteristics of the student. Digital teaching resources can be flexible in their form, content and methodology.

7.7 Digital badges and micro-credentials

Badges make it possible to assign a discrete value to smaller teaching units. This increases the flexibility of the education that can be provided: students have more freedom of choice in constructing their curriculum. Students can go looking for educational units, for which they can earn badges, that suit their own background and learning path. Especially professionals who want to continue with lifelong learning, often do not want to follow a complete degree course, but just specific parts of it. They then want to be able to provide proof that they have completed this additional training. Badges can help in recognising previously acquired skills. For employers, badges make it more transparent what education someone has completed: they make unusual skills more visible. And badges can enable clearer differentiation between formal and informal education.

7.8 The student as owner of his online identity

A good and reliable online identity is an absolute precondition for customised education. An educational identity for each student offers access to worldwide educational options without complicated and time-consuming registration procedures and difficult transfers and re-registrations. A student may specialise by taking extra subjects and additional courses at other educational institutions and simply combine study at Tokyo University with an intensive online refresher course at Munich University. A reliable identity is also important for collecting micro-credentials. Certificates and badges awarded can be linked to a single identity: that makes it simpler for a student to prove that he/she has successfully completed a course.

8 CONCLUSION

Education is due for some drastic changes in order to be better able to meet the ever-changing demands of the job market and to offer students more customised services. Institutions are moving in this direction, and revising their teaching in some wide-ranging innovative programs. But there is still much to be uncovered about the way in which education can more closely meet the demands from the job market and from students.

Where we want and need to get to with education is a difficult but important question. Insights will emerge as we work on it, and will not follow a straight line. In this paper, we have described five dimensions of customised education, we have reflected on the extreme consequences of customised education and we have asked some questions about its desirability. We also drew an outline of the way in which ICT can play a role in achieving customised education. With this, we hope we have made a contribution to the discussion of innovation in education.

We invite educational institutions to continue to share their experiences in innovation in education and to refine their own vision of education. SURFnet wants to provide an environment for using the technological options that are necessary to achieve these ambitions.

3. AUTHORS' BIOGRAPHIES

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SURFnet's objective is to improve the quality of higher education and research in the Netherlands through breakthrough innovations in ICT. SURF's policy requires it to closely monitor international trends and openly share knowledge with international partners. As programmanager Technology Enhanced Learning, Christien's field of interest and work is to support cooperation between institutions of higher education in the area of IT innovation for improving study success and the quality of education. She has a strong interest in Open Education, Learning Analytics, the Next Generation Digital Learning Environment and Testing and Assessments.
Christien Studied Dutch Literature at Utrecht University. She worked for the Dutch Foundation for Literature and was at the The Netherlands Organisation for Scientific Research responsible for a Research program in which IT researchers and heritage managers work together on making heritage available digitally.

Introducing the Learning Scorecard: a tool to improve the student learning experience

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Keywords
Student learning; Balanced Scorecard; Business Intelligence; Gamification.

1. SUMMARY

Improving the student learning experience is an essential aspect of teaching. This paper presents the Learning Scorecard (LS), a tool designed to monitor and manage the learning experience of students in a course. The LS has a student view and a faculty (or course coordinator) view. The student view essentially focuses on time management and uses gamification to engage students with the course's activities. In the faculty view, data is aggregated from the student's view, enabling the course coordinator to monitor the average progress of students in the different classes of the course he/she is lecturing. The Learning Scorecard has been developed using Business Intelligence and performance management techniques. It includes a Balanced Scorecard and dashboards for the visualization and monitoring of the student learning experience. In this paper the design of the LS will be presented as well as some initial results with an ongoing experiment in a course lectured in different Higher Education programs within the same university.

2. THE LEARNING SCORECARD

The Learning Scorecard is a performance management tool that applies the quality management principle of *"if you can't measure it, you can't manage it and improve it"*. The goal of the LS is to provide Higher Education students with an analytical environment enabling the monitoring of their performance in a course, contributing to the enhancement of the student learning experience. By measuring the individual student learning performance, the LS also enables the course coordinator to monitor the ongoing learning experience of students throughout the semester. Given its context, the LS is a case study of learning analytics, a recent research area, focusing on the measurement and analysis of "data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs," (Long and Siemens, 2011).

This project started in the spring semester of the 2015-2016 academic year, as a research project of a group of graduate students of a course on Decision Support Systems at the University Institute of Lisbon (ISCTE-IUL), a public university in Lisbon, Portugal. It is currently the research theme of two master dissertations in Computer Science Engineering. The LS has already been used to improve the learning experience of students in the Data Warehouse course, in the winter semester of 2016-2017 (Cardoso et al., 2016). Presently, the LS tool is being tested in the Business Intelligence course, lectured in undergraduate and graduate programs - an ongoing experiment that will be concluded in May 2017.

The Learning Scorecard design includes a balanced scorecard (with a strategy map and a quantification framework) and a set of dashboards for the monitoring of the student learning experience. Since the LS is designed for two "customer segments" – students and course coordinator – which have different goals, expectations and pain points, the tool provides two separate views: the student view and the faculty view. The strategy map, in Figure 1, describes the most important strategic objectives and their dependencies (called cause-and-effect relationships) in order to achieve the strategy of a course (which basically consists of achieving the learning outcomes with an improved student learning experience). In this map, there are three perspectives: Students and Faculty, Internal Processes, and Learning and Growth. The financial perspective, the fourth standard perspective in a Balanced Scorecard is not relevant for the Learning Scorecard, which is focused solely on the student learning experience. At the right end side of Figure 1, are the values that drive this strategic project, which are defined from a student's view as: pursue growth and learning, enjoying participation and self-discipline. The strategy map is draw as a “mobile phone”, as a metaphor for the portability of the LS platform. One of the design requirements of the LS relates to the portability across web browsers (Firefox, Google Chrome, Safari, Edge) including mobile devices. The development of a mobile application for the student view is also contemplated in the near future.

The strategy map is a communication tool that should be read bottom-up, starting with the objectives in the learning and growth perspective. Following all the cause-and-effect relationships in the map, we can see that the ultimate goal of the LS is to “improve student learning experience”. Each of these strategic objectives are measured by a set of KPIs (key performance indicators) that are monitored in the faculty view by the course coordinator.

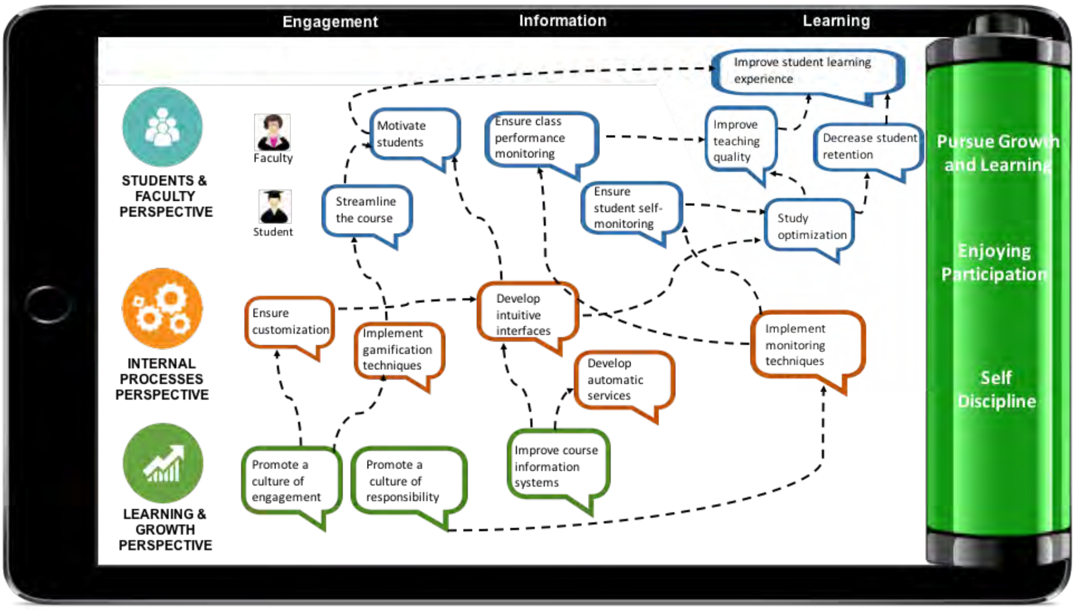

Figure 1: The Learning Scorecard strategy map

The LS uses gamification, a recent technique which is being applied to education and other sectors, that uses game design elements in non-game contexts (Deterding et al., 2011; Dicheva et al., 2015). Gamification is particularly important for the student view, and is used to engage and motivate students to experience the different learning challenges proposed by the course coordinator.

The Learning Scorecard receives data from two systems: the e-learning platform and the student academic system. An important design requirement is to have intuitive and user-friendly interfaces, in which the input data required from students should be kept to a minimum. Most of the required data is uploaded into the LS by the course coordinator, based on the course syllabus.

2.1. The student view

The LS student view focuses on time management and monitoring of the individual learning experience. Gamification techniques play a central role in the design of the student view, since the tool is supposed to be used voluntarily by students. Gamification enables the motivation of students in terms of achieving the course goals, and provides a healthy competition environment towards the best course performance. Currently, the LS uses the following game elements: experience points (XP), levels, quests or challenges, leaderboard, avatars, and rewards.

In the LS, students are divided into classes according to their program. Students begin with zero points, and are thus encouraged to learn to earn experience points, and increase their game level. Figure 2 presents an example of the entry page of the student view, for a particular student or “gamer”. In this page the student can visualize his/her performance (in points) and receive alerts about incoming quests deadlines. A summary of the leaderboard is always present (at the sidebar, in the left-down corner of Figure 2), with the top-5 gamers (ordered by points) and the ranking of classes, ordered by the number of active students using the LS. The identification of classes in Figure 2 is done using the Portuguese acronym of the program. Figure 2 presents real data (as of November 18, 2016), of a student enrolled in the Data Warehouse course in the winter semester of 2016-2017. In this semester the course was taught to four programs (respectively with the acronyms MEI, METI, IGE and IGE-PL): two master programs in the area of computer science engineering and two undergraduate programs in informatics and management.

Figure 2: The LS student view: quests and points

Students can also visualize the course planning, with a list of all planned quests, according to the course syllabus. There are mandatory and optional quests. Students receive experience points for concluding quests. Currently, the following type of quests are implemented:

- class assiduity (validated with the assiduity report generated by the student academic system; students have a university student card that needs to be activated at the location and time of the class)
- quizzes (performed using the e-learning system)
- exercises (also submitted to the e-learning system)
- practical assignment (entails a qualitative evaluation performed in a tutorial meeting with the teacher, in which students receive feedback on the development of the course’s practical assignment; for instance, in the case of the Data Warehouse course, this assignment was the development of a data mart).

The performance functionality in the student view includes three standard visualizations: progress analysis, percentage chart and radar chart. Figure 3 presents an example of the progress analysis dashboard for the top gamer at the time, in November 18, 2016 (week 9 of the semester, which comprises 12 weeks in total). Student performance is also presented in comparison with the average performance of the class, using a radar chart, as displayed in Figure 4. The percentage chart provides a visualization of the student’s current achievements versus the total amount of points that he/she could have earned so far in the different types of quests.

Student identification data privacy is an important non-functional requirement of the Learning Scorecard. That is, the course coordinator only has access to aggregated class data. What could be perceived as a missed opportunity (in terms of the identification of at-risk students) was in fact considered an advantage. The LS was mainly designed for students to support their learning experience in a course, as such in our perspective, student privacy contributes to the voluntarily use of the platform, removing any fear of faculty observation. Only the student nickname is shared in the leaderboard (see also Figure 7). Figures 2, 3 and 4 were kindly sent by students to the course coordinator for the purpose of documenting the LS usage.

Figure 3: The LS student view: performance visualization (progress analysis)

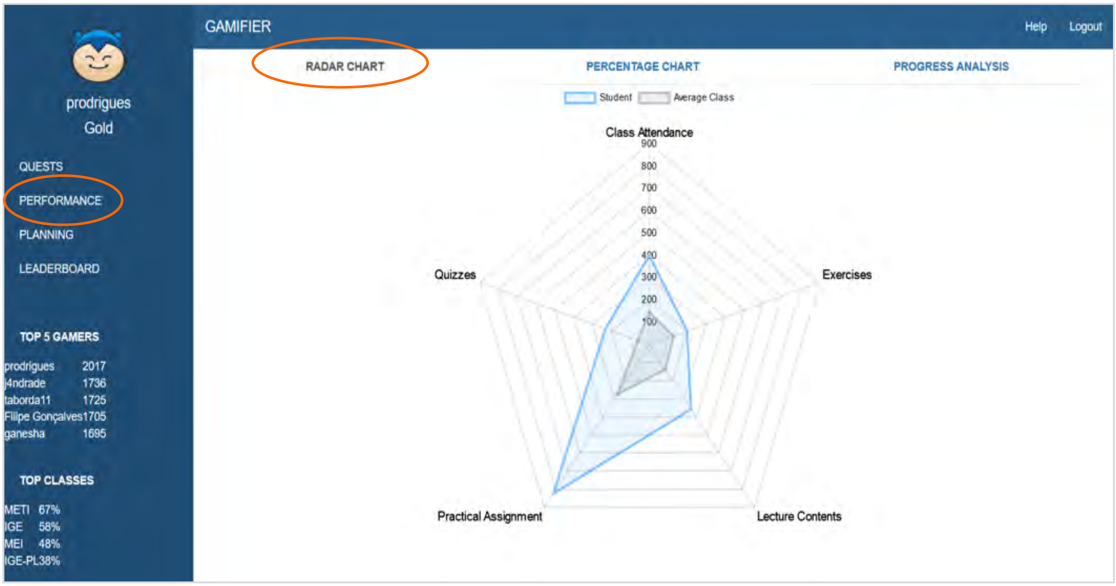

Figure 4: The LS student view: performance visualization (radar chart)

2.2. The faculty view

The faculty view is an essential part of the LS tool. The initial prototype of the Learning Scorecard only had the student view. The current version of the LS tool has both views implemented. As a result of the implementation of the faculty view some changes were introduced into the student view. In this paper the interfaces related to the student view are from the first version of the tool, whereas the interfaces described in this section belong to the second version of the tool.

In this view, the course coordinator can increase the communication with the students and customize their learning path. Figure 5 presents the planning functionality, in which the course coordinator can insert the list of quests for the course. This list will be later available in the planning option of the student view (see the sidebar in Figure 2 for example). Each quest has a type and a number of points that can be awarded. Figure 6 also presents the list of quests but using a timeline format. This is a new functionality, which is also available in the student view. The data displayed in Figure 5 is just test data, whereas Figures 6 and 7 display the current data in the platform.

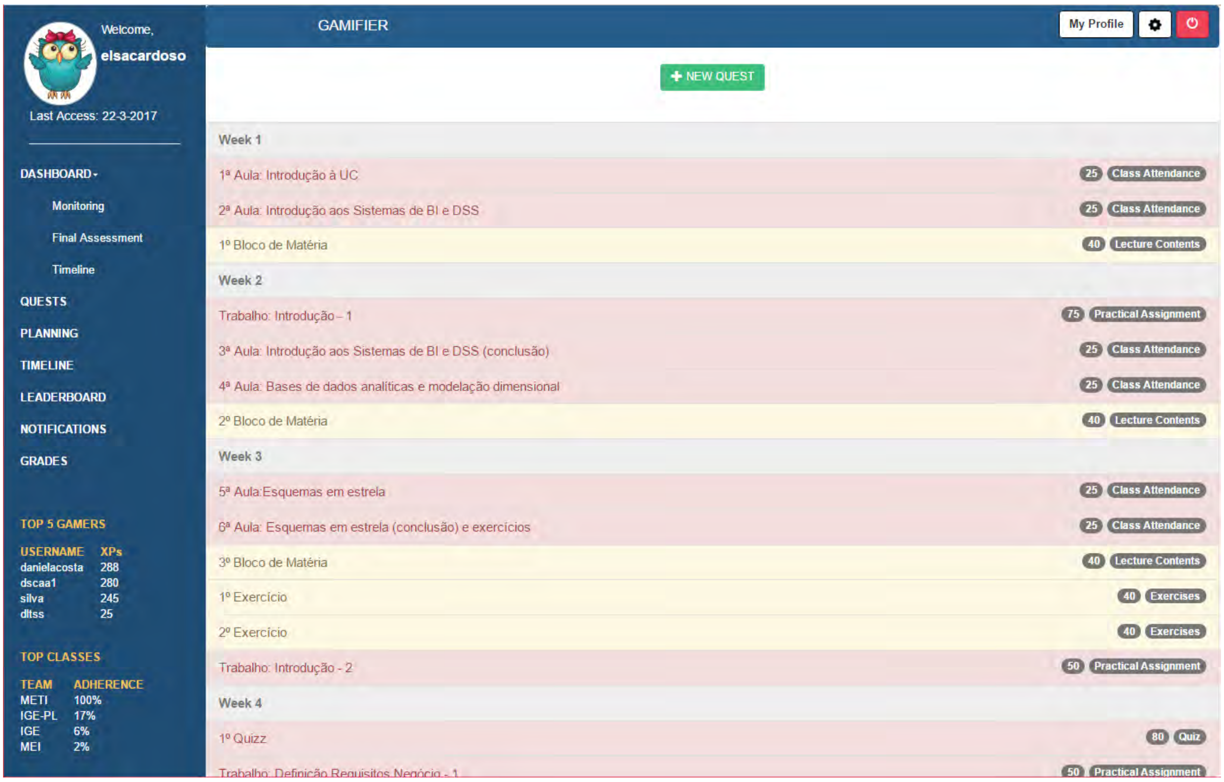

Figure 5: The LS faculty view: planning of all quests

With the Learning Scorecard the course coordinator can monitor the progress of students in terms of the following dimensions:

- Engagement
- Student motivation
- Student responsibility
- Study optimization
- Learning feedback
- Student collaboration

The monitoring functionality can be analyzed in average, considering the performance of all students enrolled in the course, or filtered by class. The LS is currently applied to courses that are taught to students of different programs. Hence the idea of using gamification to explore the "natural and healthy" competition among students from programs in related scientific areas.

Engagement is measured by three indicators: percentage of students registered / active / and inactive in the LS. Student motivation is measured by the average number of points (XP). Responsibility is measured by the number of quests performed and the average quest delay. Study optimization is measured by the percentage of completed quests within the course milestones. The learning feedback is calculated in terms of the average grade of the quizzes. Finally, student collaboration is assessed by the number of points awarded in posts submitted to the course's forum (in the e-learning platform).

The faculty view is essential for the validation of quests. Class attendance, forum participation and and practical assignment are evaluated by the course coordinator. Assiduity data is imported from the university academic system. XPs gained through the participation in the course's forum are introduced at the end of the semester. Each student will earn a percentage of the maximum number of 5000 XP, according to their participation (an excellent performance earns 100% of the forum XPs, a very good performance 80%, good 60%, satisfactory 40% and finally an inactive student receives 0 XP). There are also extra XP to grab in the forum. Extraordinary posts, that contribute to the collective learning of the class are awarded with 350 XP (each).

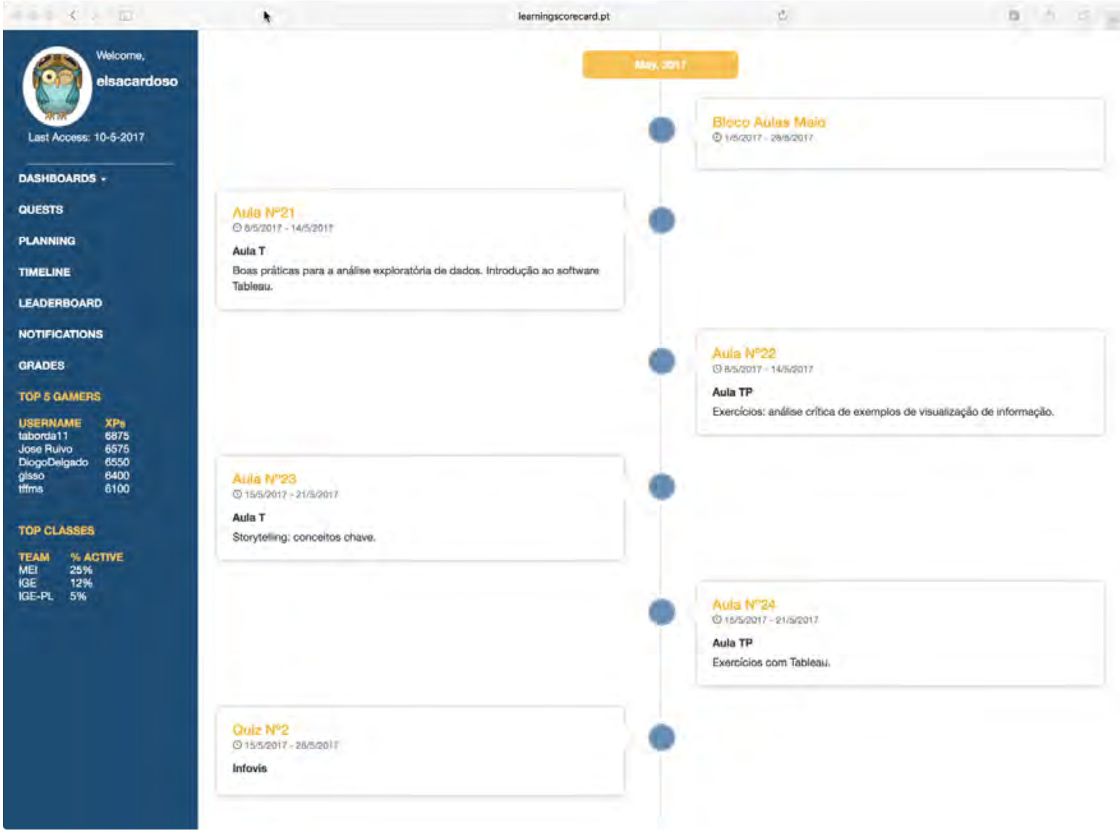

Figure 6: The LS faculty view: timeline

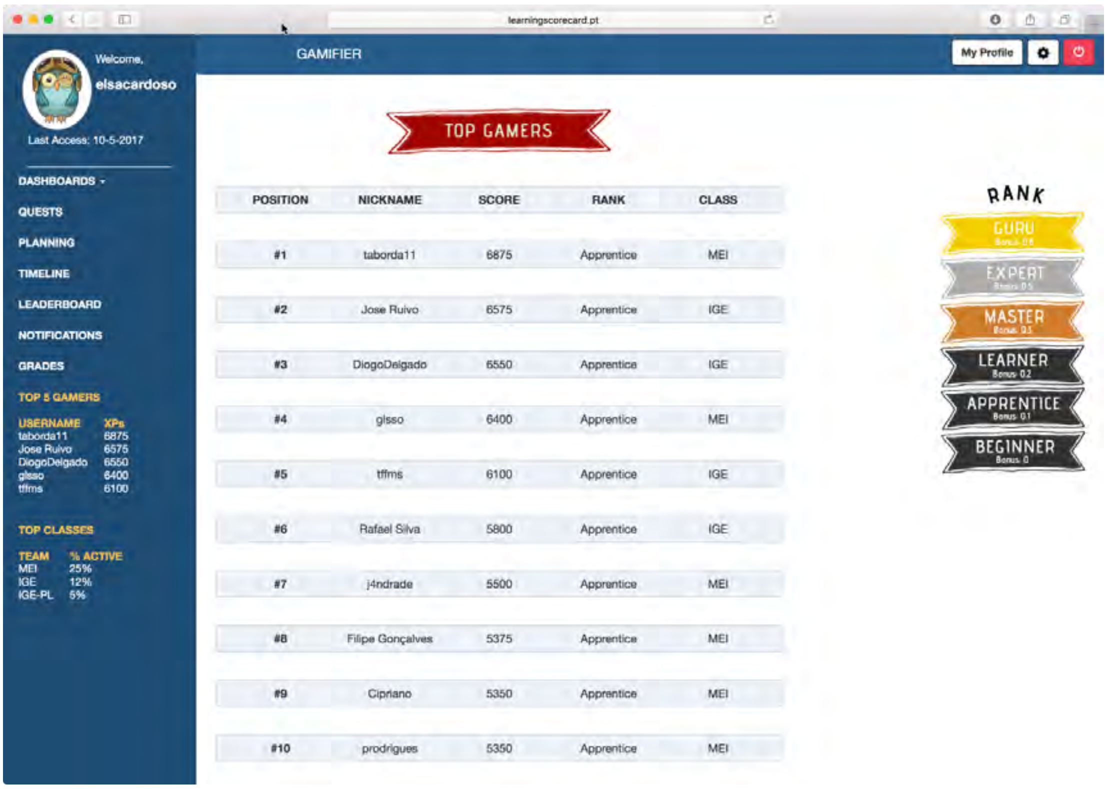

Figure 7: The LS faculty view: leaderboard and student ranks

3. PROTOTYPE DEVELOPMENT AND EVALUATION

Figure 8 describes the development process of the LS, which began in the Spring semester of the 2015-2016 academic year (more specifically in April 2016). The result of this initial development phase was LS version 1 (v1), only with the student view. This version was tested by an initial group of 110 students in a Data Warehouse course (labelled Course I in Figure 8), lectured in the 2016-2017 fall semester to four different programs. Data was collected from October to December 2016. At the end of this pilot study, students were asked to fill in an online questionnaire to assess student engagement, motivation, and satisfaction with the course and the LS platform. The feedback gathered from these questionnaires was essential to drive the next phase of development, which will be concluded by the end of March 2017. LS version 2 (v2) comprises both the student and faculty views. This new version will be tested in another course (labelled Course II in Figure 8), focusing on Business Intelligence and Data Visualization, which is also taught to students from (three) different programs. The coordinator of both courses is the same, which ensures a continuity in terms of the evaluation of the LS. The second study pilot will occur between April and May 2017. In June 2017, a new round of questionnaires will be sent to students to evaluate the performance of the tool and their perception of the impact of the LS to improve the learning experience.

The real impact of the tool can only be assessed with more case studies and in several academic years. Nevertheless, the impact on student grades will also be studied, in terms of final grades as well as partial grades (e.g., practical assignment and individual test), according to the pedagogic methodologies used in the courses. Taking this aspect into consideration, the initial selection of courses to evaluate the LS has already considered courses with similar pedagogic methodologies.

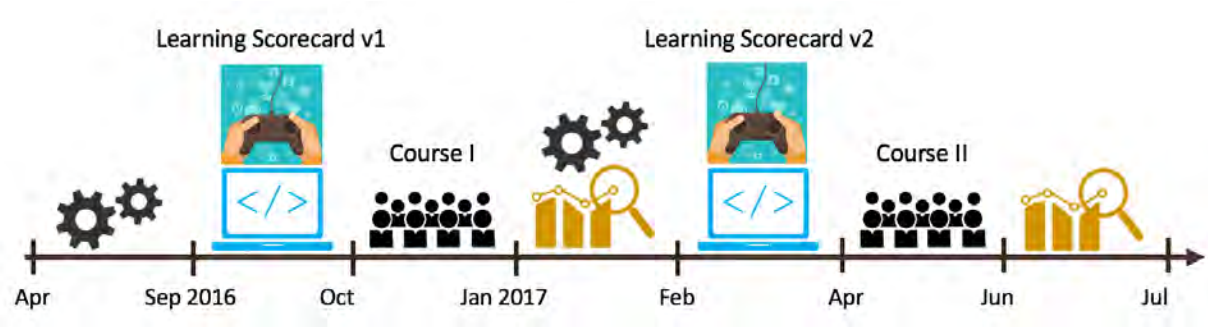

Figure 8: Learning Scorecard development and evaluation timeline

The LS platform was developed using Node.js. The front-end was developed using HTML and CSS. Javascript, specifically Express.js, was used for the back-end implementation. Several modules were used: Bootstrap, for platform design, Chart.js, for the implementation of the charts in the LS dashboards, Passport and Crypto, for secure authentication of students in the LS. The LS platform also includes a MySQL database.

3.1. LS version 1: feedback from students

At the end of the first pilot, students answered a questionnaire to evaluate the experience. The questionnaire was sent to students enrolled in the Data Warehouse course, and 54 students answered it, accounting for a response rate of 49%. Of these 54 students, only 37 (68.5%) had previously registered in the LS platform. The reasons for not having registered were: lack of time (main reason), and lack of interest or awareness of the platform.

Only 16.2% of students used the platform until the end of the semester, whereas 45.9% used the LS between two and four weeks[1]. When asked about the reasons why their motivation to use the platform faded, students provided the following feedback: "I missed one quiz and thought that I couldn't win

[1] A semester comprises 12 weeks for lecture time.

the final top 3 rewards, so I gave up…", lack of time, "lack of motivation after the hacking situation…", validity of quests was ambiguous. The LS platform was hacked during the first pilot, after only two weeks of being online, and data from quests was lost. As a result of this incident, a significant number of students did not resume their game. The security of the platform was improved, but this issue had a major impact on the number of active students.

Despite the low usage figures, when asked if they enjoyed using an academic platform with gamification, 75% of students answered positively.

The received feedback was crucial to the improvement of the LS platform and the second pilot. Special attention was given to the previous reasons that led to the low adoption of the LS in the first pilot. The reward system was changed: the reward is now available to all gamers in a proportion of the total XP earned, as opposed to a top-3 ranking or podium (see Figure 7).

Another important aspect was the validation of quests. Most of the improvement suggestions received from students was related to the type of quests and their validation in the platform. All the received feedback (44 suggestions) was taken into consideration, which led to a much richer second version of the LS. In this new version of the platform, data input by students has been minimized, and unnecessary quests or quests which could not be objectively validated were deleted (such as the reading of slides or papers). The original mindset and values of the LS platform are: "pursue growth and learning", "enjoying participation" and "self discipline", as displayed in the strategy map of Figure 1. Students were supposed to validate only the quests they had actually performed - "self discipline" - only then the LS could be used to monitor their own learning path. However, students didn't perceive the "self discipline" part, and acted mainly with the reward in mind. With the new reward policy implemented it will be very interesting to see if the students' behavior will be different in the second pilot experiment of the LS platform, which is currently ongoing.

Notifications have been implemented in the faculty view, so that alerts can be issued when quests are about to end. The usability of the interface was also improved.

When questioned about *"how important is student data privacy for your participation as a gamer in the LS?"*, about 42% of students considered it important (33.3%) and very important (8.3%). In contrast, 27.8% considered data privacy not important and 8.3% even said it was totally unimportant. Regarding this issue, there are mixed feelings amongst the students, however, we decided to continue to ensure student data privacy.

Students mentioned that the LS and the e-learning platform should be completely integrated. For some of them, having two platforms was confusing. This is a very important remark. Blackboard is the e-learning platform used at ISCTE-IUL. All the functionalities that were already available in the e-learning platform were not programmed into the LS, for instance, quizzes and the forum. Regarding quizzes, the grades are imported to the LS, and students are only asked to evaluate the difficulty of the quiz (in a scale of low, medium, high).

4. CONCLUSIONS AND FUTURE WORK

This paper presented a new tool designed to improve the student learning experience, the Learning Scorecard. The LS receives data from the e-learning platform used at the university and the student academic system (for the assiduity data). The e-learning platform is used to run quizzes and specific challenges (such as practical exercises), and also to encourage student collaboration via the course's forum. The LS was designed to complement the e-learning platform, adding game elements to the student view to increase their motivation and engagement with the learning process. For the course coordinator, the LS provides a comprehensive and customized view of the learning experience of students that significantly extends the current functionalities available in the e-learning platform used in the university.

A lot is planned for future work. Research is being developed in terms of the reward mechanisms integrated with game dynamics, with the purpose of increasing and maintaining the motivation of students to use the tool, and ultimately pursue a better final grade. The goal of the Learning Scorecard is to improve the student learning experience, as a process but also as an outcome. In the future, the LS may also be applied to other courses in different scientific areas, other than Decision Support Systems and Business Intelligence (for instance, in Mathematics and Architecture). The development of a mobile app for the student view is also planned for the next academic year. It is also possible to generalize the use of the Learning Scorecard to other universities, however, significant development is required. The concept of the LS is very rich; another group of students is currently developing a new module to study academic success and the link to pedagogic practices in courses using data from one program. The original ideal behind the development of the LS was to actively involve students in the learning process, making them aware of the key factors that impact their learning experience in Higher Education. At the same time, the LS platform is also a great example of a business intelligence and learning analytics application, attempting to measure and manage indicators of the learning process, which is something that students can relate to.

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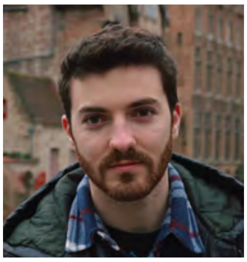

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How to create a digital learning environment consisting of various components and acting as a whole?

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Digital Learning Environment, Architecture, Interoperability, Standards, Functional Model

1. ABSTRACT

Many institutions strive to provide education that matches the learning needs of each individual student. This places high demands on the digital learning environment (DLE) of an institution. One system that meets all the needs and requirements of every student and lecturer, does not exist, which is why a modular approach seems the obvious choice.
In 2016, SURFnet translated this modular approach into a functional model for the DLE. This resulted in thirteen components for the DLE, that support several educational processes. Splitting the DLE into components is supportive for institutions in two ways: 1. It helps institutions to decide to what degree of control and management the components have to be placed in the architecture of the digital learning environment; 2. It helps institutions to determine in which way the components are connected and able to interact.
These connections and interactions are defined in a functional model. In this functional model, the following standards are essential: IMS LTI for Interoperability and Integration, IMS LIS for Personalization, xAPI for Analytics, Advising, and Learning Assessment, SAML/VOOT for Collaboration and OOAPI for Accessibility and Universal Design.
By doing this, SURFnet created a frame of reference for institutions, that helps them with the development of their own digital learning environment. To gain hands-on experience with a modular learning environment, we developed a “demo-DLE”, based on the functional model, which demonstrates the possibilities of a modular DLE for education.

2. INTRODUCTION

Many institutions for higher education aspire to make education more personal and more flexible. They also strive to provide education that matches the learning needs of each individual student. This places high demands on the digital learning environment (DLE) of an institution.
One system that meets all the needs and requirements of every student and lecturer, does not exist, which is why a modular approach seems the obvious choice.

Educause (2015) suggests a “Lego” approach to realizing the digital learning environment, where the DLE consists of several interchangeable and expandable components. These components give individuals and institutions the opportunity to construct learning environments tailored to their requirements and goals.

In 2016, SURFnet translated this vision into a functional model for the DLE. Together with technical architects of several institutions, we defined thirteen components, that support several educational processes. Then, we defined the interoperability between them and placed the components in a functional model. By doing this, SURFnet created a frame of reference for institutions, that helps them with the development of their own digital learning environment. To gain hands-on experience with a modular learning environment, we developed a “demo-DLE”, based on the functional model, which demonstrates the possibilities of a modular DLE for education.

SURFnet is the Dutch National Research and Education Network (NREN) representing all Dutch institutes for higher education and research. SURFnet's mission is to boost the quality of education and research through the support, innovation, development and operation of an advanced, reliable and interconnected ICT infrastructure, enabling the potential of ICT to be harnessed to its full extent. One of the innovation topics which SURFnet addresses, is the Digital Learning Environment. This is done in a multi-year innovation program in which all institutions for higher education can participate.

In this paper we present the components of which a DLE can consist, we present the way the components can interact with each other in a functional modal. We will conclude with the setup of the "demo-DLE".

3. COMPONENTS OF A DIGITAL LEARNING ENVIRONMENT

The modular digital learning environment will consist of a variety of (often pre-existing) components that students and teachers canuse as needed. Some components will be available to all students and teachers at an institution, and others need autorization. The components must also be interchangeable and expandable, so that the learning environment can always be adapted to the latest developments in education and to technological innovations.

We use the term 'component' to denote the specific functional elements that can be used to construct the digital learning environment. These components have been classified in a way that is familiar to the education sector, following the 'education application model', which is one of the reference models in the Higher Education Reference Architecture (HORA). This is a reference architecture specific to the higher education sector. Institutions can use the HORA as a guide for their own organisational structure and information management. It was designed by university IT architects in collaboration with SURF and is managed by the higher education architects consultation platform ('Architectenberaad HO'), which is currently working to develop the teaching component in various models.

A component is not the same as an application. Some applications can be used for several components at the same time, such as the Learning Management System (LMS). An LMS combines components such as communication, collaboration and submission and assessment of assignments. However, some applications cover a single part of a component. One example is plagiarism checking, which falls under 'Submission and assessment of assignments'.

In this section describe the significance of each component and exactly what it entails.

3.1. Organisation of learning

The 'organisation of learning' component (or: learning management) is about making sure students have clear and easy access to the correct content and applications they need for their studies. This includes functionalities such as assigning students to groups, assigning students (or groups of students) to courses and arranging access management. The organisation of learning is a key aspect of learning management systems.

3.2. Testing

Digital testing can improve the quality of learning and testing in education. Within the 'testing' component we could also differentiate between four subcomponents: an author environment, a playback environment, an analysis tool and an item bank. Crucially, the digital learning environment will have to support various testing methods.

The testing component must be set up in such a way that a distinction can be drawn between summative testing, meaning tests resulting in a formal assessment, and formative testing, which is about collecting information on students' progress in order to subsequently adjust their learning process.

3.3. Submission and assessment of assignments

Assignment submission functionality is key within any learning environment, which can be provided by an upload tool, for example. This component must also include functionalities for managing the submission and evaluation process such as setting and communicating deadlines (approaching deadline alerts, automatic inclusion of deadlines in student calendars), allocating first and second assessors, coordination between assessors, providing student feedback, awarding marks, assessment notifications and the option for students to appeal decisions.
One indispensable application for checking assignments is plagiarism detection. Many faculties use tools to automatically check students' work for plagiarism. Students themselves are sometimes also able to perform plagiarism checks to verify whether they have referenced their assignments properly and whether fellow students with whom they have collaborated have done so as well.

3.4. Management and use of student information

The 'management and use of student information' component involves both the management of administrative student data (e.g. personal details) and the registration of marks, progress and attendance. An integrated digital learning environment requires basic data – i.e. the registration of student details, progress data and even schedule information – to be well-organised. Meaning stored and managed according to a fixed standard. Only then will it be accessible from multiple applications.

3.5. Timetabling

In essence, timetabling is about reaching the best possible distribution of time and resources across teachers and students. Flexible and personalised education changes the requirements in this respect, due to an increase in demand-driven learning and in diverse and personalized learning pathways. Responding effectively to these changes represents a challenge to institutions.

3.6. Internships and final projects

Internships and final projects are a part of all degree programmes in the Netherlands. The 'internships and final projects' component provides the functionality for evaluating the match between the internship/final assignment, the host organisation and the student. Other internship functionality must also be included, such as contract and document management, progress monitoring and relationship management.

3.7. Developing, managing and sharing learning materials

There can be no education without learning resources, which may consist of texts, images, tests and audio and video material. This component concerns functionalities for the development, management and sharing of learning materials.

3.8. Education process support

Education process support concerns tools used for monitoring students' progress and giving them targeted feedback to support their learning process. Interviews with students regarding next-generation learning environments have revealed that they are assessed on their final products too much and not enough on their learning process. This approach can be particularly counter-productive when it comes to group assignments completed with other students, when it can be very tempting to divide the work so that each student plays to their own strengths, ultimately reducing the opportunities for learning. Many institutions work with digital portfolios that are intended to promote student learning by monitoring their development, providing feedback and gathering materials (often by students themselves) to demonstrate it.

3.9. Learning analytics

The learning analytics component concerns applications that collect and analyse information on students' learning process in order to gain insight into and improve teaching and learning processes.

This includes applications that can collect, save and analyse data, and applications that can visualise and present these analyses.
Various components of the digital learning environment collect student data, and this has to be standardised in order to allow analysis and interpretation. As learning analytics are necessary to facilitate personalisation and personal learning pathways, the ability of all components to provide standardised data will be essential to education in the future.

3.10. Communication

Communication is an essential part of all types of education and involves sending messages and information and starting dialogues. For teachers, it is important to be able to contact entire groups of students at once. It must also be possible to communicate with students, colleagues and other contacts one-on-one. Students have to be able to get in touch with teachers, supervisors, fellow students and other contacts. Likewise, departments, faculties and institutions need to be able to send information to students and student groups.

3.11. Collaboration

Collaboration in education is becoming increasingly important as it enriches and enables greater depth of learning. A digital learning environment must therefore offer enough opportunities to facilitate collaboration of all kinds. Examples include cross-institutional collaboration, remote collaboration on documents, the mutual provision and evaluation of feedback, and the shared discovery and use of content from outside the institution. Joint learning as part of MOOCs and other learning communities must also be possible, requiring effective group management.

3.12. Multimedia

Video and other multimedia applications like Virtual Reality, 3D-printing and so on, are playing an increasingly important role in education. Video uplinks sometimes allow lectures to be attended remotely in real time. Students themselves also create video footage for assignments or to demonstrate their progress. This component must include functionality management and playback functionality for several multimedia resources.

3.13. Freely available applications

In addition to the applications and systems provided by institutions, students and teachers also use social media, software and apps in their learning process, including apps they create themselves. Institutions can take advantage of this by facilitating the ongoing addition of new tools to their digital learning environment, requiring them to place a specific focus on the integration of these types of applications. Some institutions choose to assess applications individually to determine if they should be integrated into the learning environment.

4. THE USEFULLNES OF HAVING COMPONENTS DEFINED

Splitting the DLE into components is supportive for institutions in two ways:

1) It helps institutions to decide to what degree of control and management the components have to be placed in the architecture of the digital learning environment;
2) It helps institutions to determine in which way the components are connected and able to interact.

Both the decision on the degree of control and management and the determination of the interoperability of the components are described in the following paragraphs.

4.1. The metaphor of the fortress and the open city.

Regarding to the considerations of the DLE of an institution, SURFnet developed the metaphor of the fortress and the open city. It compares the learning environment to the medieval formation of a city surrounding a fortress. This metaphor demonstrates that the degree of control and management of the different components varies within the institution.

The FORTRESS itself covers everything that is subject to centralised management (across the institution), and for which the institution is accountable. This includes functions where strategic information is processed as well as formal information for which the institution is held accountable by third parties.

Figure 1: The metaphor of the fortress and the open city

This information is documented in the core components. The fortress is characterised by limited freedom and an aim for standardisation. This standardisation enables a flexible approach to the digital learning environment.

In the CITY, research, studying, learning and working take place with the help of information from the fortress. There is more freedom in the city, and management is often decentralised (taking place within services, faculties, degree programmes and teams). However, the institution still sets criteria that must be met.

In the COUNTRYSIDE surrounding the fortress and the city, it is users themselves who decide what they do, with no interference from the institution.

In 2016, SURFnet has given each component a score on the desired Confidentiality, Integrity and Availability of the data within the component. Components with a high score in one (or more) of the three areas are placed in the fortress. These are the components over which the institution requires the greatest degree of control. The components that are placed in the city have a medium or low classification, and stand in direct relation to the execution of education. They also handle known data over which a certain amount of control is required. Typical countryside components are those with a medium or low classification that involve unknown data.

Table 1: CIA classification of the components

	Confidentiality	Integrity	Availability	Most important business object/ piece of data
FORTRESS				
Organisation of learning	Low	High	Medium	Learning activity
Testing	High	High	High	Test material
Submission and assessment of assignments	Medium	High	Low	Test result
Management and use of student information	High	High	Medium	Participant
Timetabling	Low	Medium	High	Timetable
Learning analytics	High	Medium	Medium	Learning activity report*
CITY				
Developing, managing and sharing learning materials	Low	Medium	Medium	Learning materials
Education process support	Low	Medium	Medium	Progress
Internships and final projects	Low	Medium	Medium	Internship/final project activity*
COUNTRYSIDE				
Communication	Low	Medium	Medium	-
Collaboration	Low	Medium	Medium	-
Multimedia	Low	Medium	Medium	-
Freely available application	Low	Medium	Medium	-

The classification shows how the components can be positioned within the IT landscape of the institution. Next, the interoperability of the components can be defined. This will be described in the following paragraph.

4.2. Connection and interaction between components

Components consist of a number of functionalities, and these communicate with eacht other, even across components. In order to structure and streamline this communication, it is a good idea to use standards. SURFnet (2016) defined for each component, which data can flow in and out and what standards apply to this exchange of data. This resulted in the creation of an exemplary implementation model that can be used when establishing a digital learning environment.

For each component we described where it stands in relation to other components. We indicated which data the component generates and uses, whether is is in- or outgoing data and what standards can be applied for this purpose.

The figure below shows an example of the 'Testing' component.

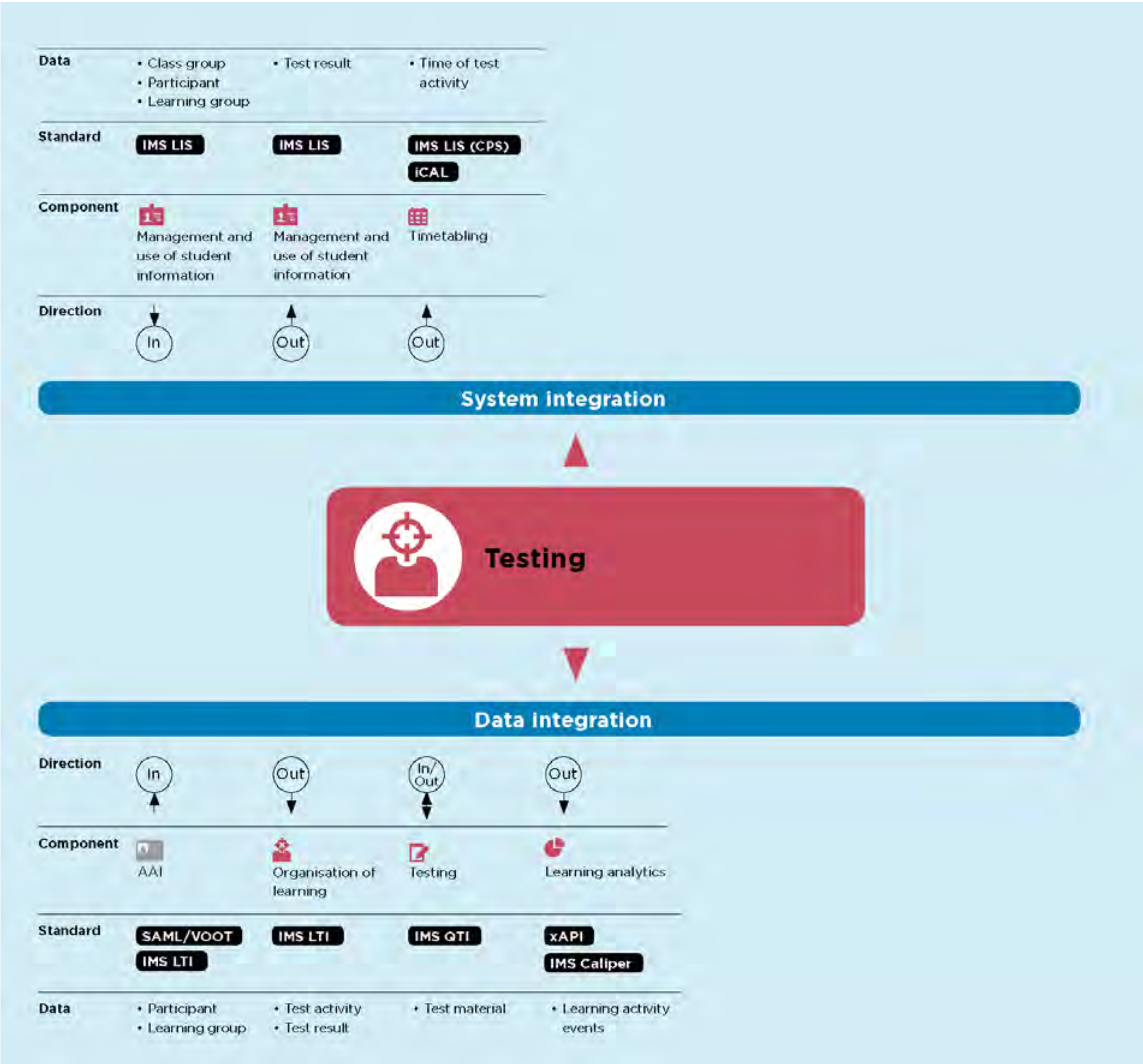

Figure 2: Overview of standards and data flow of the 'Testing' component

The description of each component brings to light the mutual dependency of the components. A component requires certain data from other components in order to function properly. This means that a component has ownership of particular data. This component must then be able to supply this data.

In the example of the Testing component, it is shown that it relies on participant and group data from the ‘Management and use of student information’ component, which is supplies using IMS LIS on the System Integration level. The Testing component provides in return the test result data to this component.

This underlines the mutual responsibility of components for one another. This interlinkage between te components can be illustrated in two ways:

First, figure 3 ‘system integration’, depicts the interconnections between the core components with the first most relevant standard. The data that usually is exchanged regards student, group and course data as well as test results and unit of study results. This type of integration mostly takes place in the confinement of the fortress, and is based on the IMS LIS/OneRoster specification. Access to this type of data from outside the fortress is achieved through the authentication and authorization infrastructure (AAI) and other means of integration.

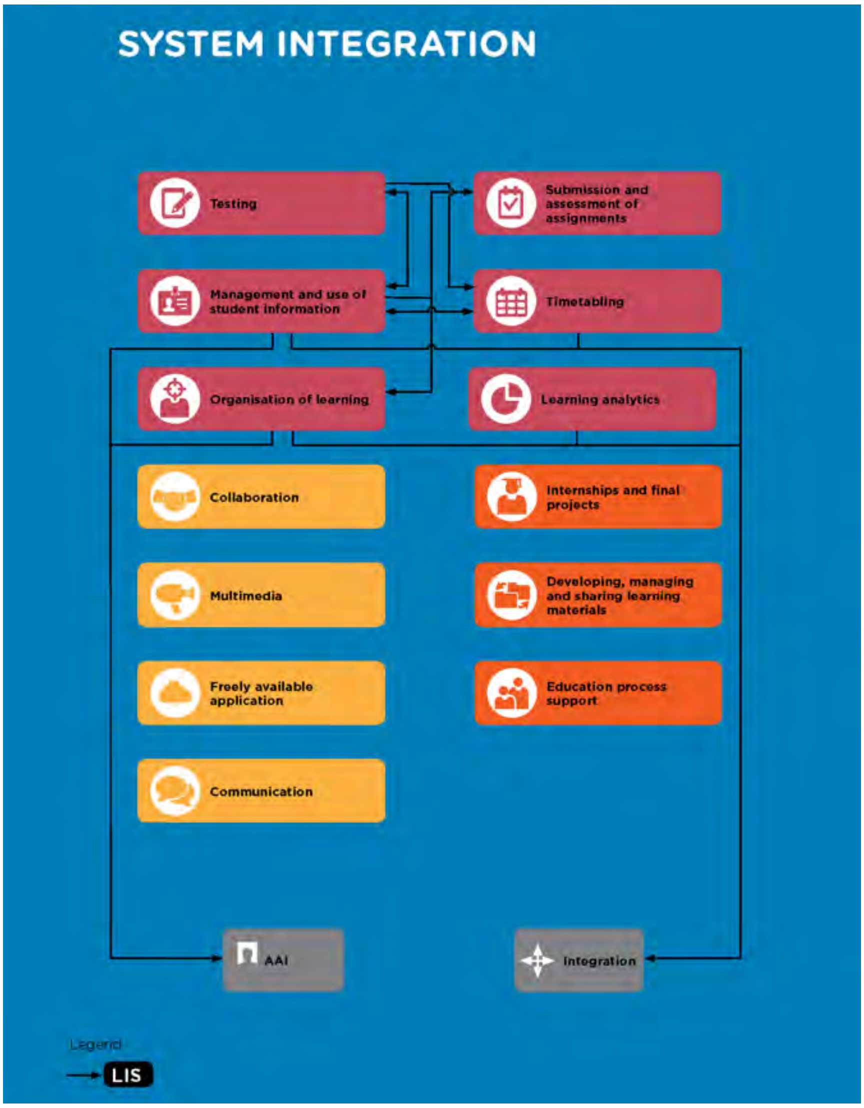

Figure 3: System integration

Second, the figure 'data integration' depicts the other most relevant standards for data exchange between the different components. Information handeled by the fortress components is provisioned to other components in the city and country side by means of integration with the Open Educational Apllication Programming Interface (OOAPI). The further shaping of organisation of learning is realized through IMS Learning Tools Interoperability (LTI).
This specification enables components to start and provides them with relevant data, such as personal data and group data. Furthermore LTI offers the possibility of responding with student results achieved in a component to the component that initiated it, for example 'organisation of learning'. The aggregation of all students' learning activity events generated by different components into learning analytics is achieved through xAPI. Authentication and authorisation of all users of components can be done by means of SAML/VOOT.

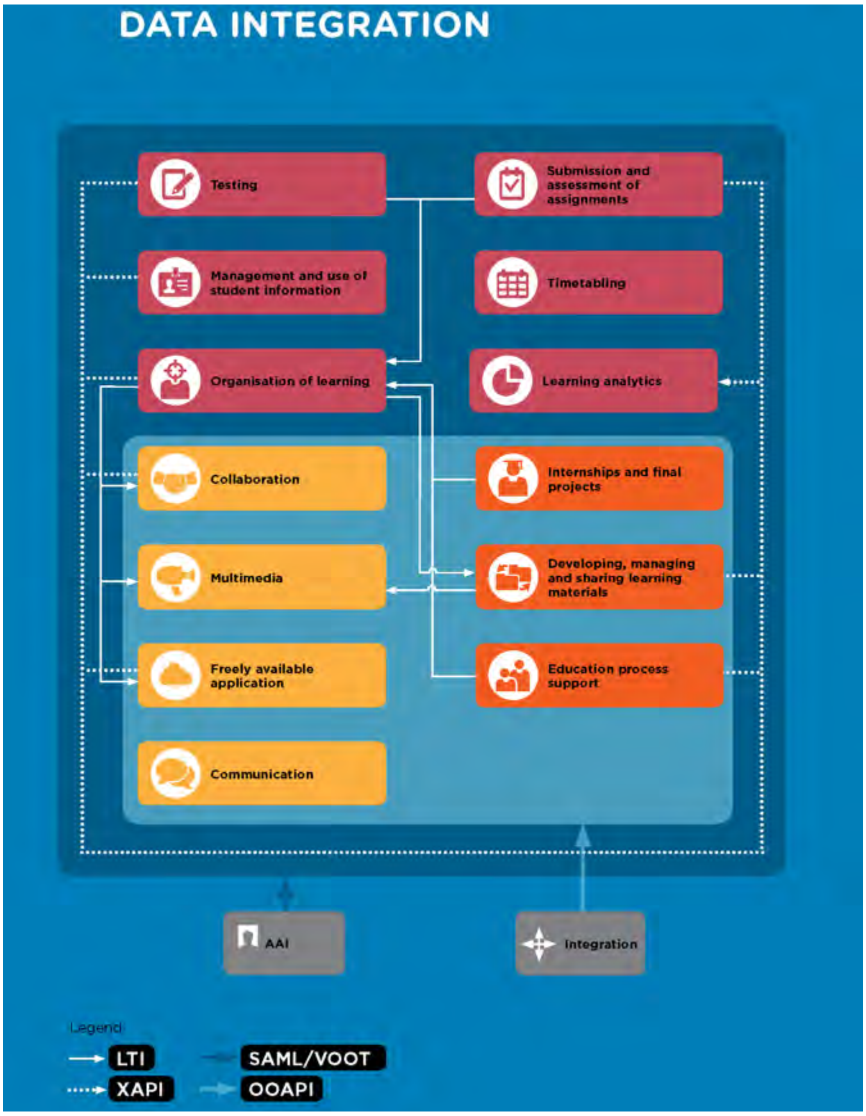

Figure 4: Data Integration

4.3. The role of standards in the digital learning environment

The use of standards ensures that the links between the various components are uniform. The standardisation of data exchange means that components can be used flexibly and are interchangeable. This gives institutions more freedom to select different components and suppliers. Standards also improve the accessibility of information. As data is displayed in a predictable manner, it is easier for new suppliers or even individual students to process information from the learning environment.

Thanks to this combination of flexible use of the components and improved access to information, students are able to exert greater influence on the architecture of their learning environment.

In practice, to make effective use of standards, we also need to bear in mind their maturity and (market) adoption. Because if a standard is used rarely or not at all, there is little chance that an institution will be able to find enough parties to exchange data with on the basis of this standard. The implementation of standards is not an easy process. It is often not just a question of technical interconnections, but also of processes and the handling of information.

The five standards of our functional model reflect the five dimensions of the DLE as proposed by ELI (2015) as follows:

1. LTI for Interoperability and Integration
2. LIS for Personalization
3. xAPI for Analytics, Advising, and Learning Assessment
4. SAML/VOOT for Collaboration
5. OOAPI for Accessibility and Universal Design

There is awareness of many of the specifications and standards within the higher education world. However, this knowledge and experience is not widely disseminated and is not always easy to locate. There is often experience with specific components, but a broader foundation is required in order to adopt an integrated approach.

To support institutions with their implementations of the digital learning environment, and to gai hands-on experience in an integrated approach, SURFnet developed a Demo DLE. The setup of this Demo DLE is described in the next paragraph.

5. DEMO DIGITAL LEARNING ENVIRONMENT

Many institutions endorse the idea of a DLE consisting of interchangeable and expandable components. In some settings, they already experiment with this thought. But when the learning management system has to to be replaced, most institutions still opt for an all-in-one system.
On the one hand, this is because there is nothing on the market that fully supports this idea. Vendors do offer (parts of) packages, but these are often not interoperable with other systems.
On the other hand, the requirements for the learning environment within the institutions are not well defined.
Institutions and suppliers must therefore be supported by both developing a vision of the modular digital learning environment and technical development. To match applications on the component model, the applications need to fulfill the main functionality of the components and need appropriate ways to interact with other components to exchange data. The Demo-DLE contributes to this matching because of the possibility to gain hands-on experience with the modular learning environment.

The setup of the Demo-DLE is designed for institutions as well as for vendors. It offers three instances for:

1) Teachers; teachers have to use the learning environment that is offered by the institution, which usually does not fully meet the needs of the teacher. Often, a teacher also wants to use tools on the course that are not available within the learning environment. An environment in which a teacher can choose the tools and applications that are important at the time, seems like a good solution here. The Demo-DLE helps teachers to gain experience with this process and SURF can explore whether this really fills a need.
2) People of the IT department managing a digital learning environment; When implementing a modular learning environment, integration issues play a major role. With the Demo-DLE, IT departments are able to do experiments with integration between the components.

3) Service providers; the success of a modular learning environment depends on the availability of tools that are actually integrated. The modular learning as a service provides vendors the opportunity to test wheter or not the integration works.

In the next couple of months, SURF invites institutes and service providers to experiment with the demo DLE. We expect that we can present the first results of the experiments during the conference.

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Reliable e-Assessment with GIT - Practical Considerations and Implementation

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Computer based examinations, Computer aided examinations, e-Assessment, e-Learning, BYOD, GIT, SOA

1. ABSTRACT

The introduction of e-Assessment is hindered by reservations, despite e-Assessment being a valuable tool for teaching and examining in general. These reservations concern mainly the fairness and reliability of e-Assessment as well as financial questions. The latter can be solved in practice by utilizing BYOD, since most of today's students already possess devices that are capable of being used for e-Assessment. This poses, however, additional challenges to the fairness and reliability of e-Assessment. This paper presents an approach that utilizes cryptographic methods, like public key cryptography and digital signatures, and the version control system GIT in order to overcome this challenges. Based on these techniques a framework for e-Assessment was implemented as client-server architecture.

2. MOTIVATION

In accordance with the general trend in society, teaching at institutes of higher education in Germany is increasingly digitized (Hochschulforum Digitalisierung, 2016). This development has different manifestations, for example the usage of learning management systems (Hochschulforum Digitalisierung, 2016) or mobile apps (Politze, Schaffert, & Decker, 2016). The incorporation of digital elements, however, is not limited to lectures, but also tutorials keep up with this trend. In programming exercises, for example, it is rather common that the students can work on the assignments with their own devices. Despite e-Assessment being already a part of lectures in form of self-tests and formative assessment, it has not yet been established for examinations (Hochschulforum Digitalisierung, 2015). The same situation has also been reported for other countries, like the United Kingdom (Walker & Handley, 2016), Greece (Terzis & Economides, 2011), the United States of America (Luecht & Sireci, 2011) and Australia (Birch & Burnett, 2009). Hence, there is a media disruption between lectures and tutorials, which are digitized, and examinations, which are in general not digitized. Figure 1 illustrates this situation.

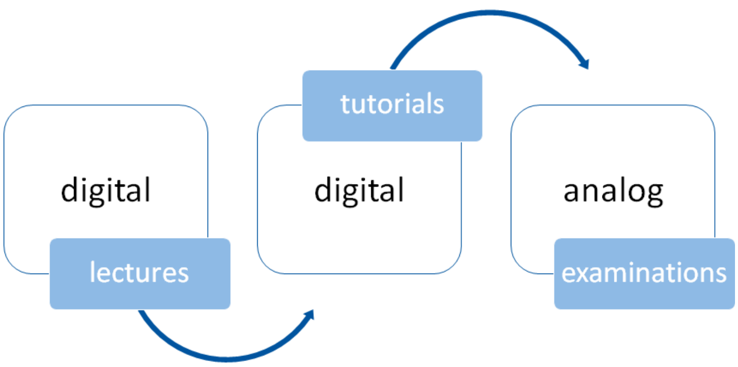

Figure 1: Current state of the digitalization in university courses.

Staying with examinations on paper is mainly caused by two reasons: Reservations against e-Assessment and money. The reservations concern mostly the fairness and reliability of digital examination systems (Vogt & Schneider, 2009). Reservations hinder the introduction of e-Assessment quite drastically, since acceptance, especially by the students, is one important key factor for the success of e-Assessment (Fluck, Pullen, & Harper, 2009) (Terzis & Economides, 2011). Beyond reservations against e-Assessment, the costs for maintaining a centrally managed IT infrastructure for e-Assessment hinder the introduction of e-Assessment additionally, since not every institution can afford the money for the hardware and the administrative effort. That those costs are quite high is reported by several institutes of higher education, which maintain a centrally managed IT infrastructure for e-Assessment, for example the University of Duisburg-Essen (Biella, Engert, & Huth, 2009) and the University of Bremen (Bücking, 2010).

E-Assessment, however, offers also significant benefits, making it worth considering. Especially in computer science education, the introduction of e-Assessment provides remarkably benefits. First and foremost, e-Assessments bring the main subject of study, namely the computer, into the examination, but there are also other facets, which improve the setting of the examinations for both, students and lecturers.

Often, tutorials are held in addition to the lectures to provide hands-on experience besides theoretical education. These tutorials introduce domain specific tools to the students. In a programming course, the students normally get used to integrated development environments, e.g. Eclipse or NetBeans, during the tutorials, but are currently most often asked to write the examinations on paper. Therefore, these tools can also be used in the examinations, closing the previously described gap between tutorial and examination.

The same tools that the students can use throughout the examinations, are also available to be used by the correctors, reducing the effort for correction considerably (Jara & Molina Madrid, 2015) (Vogt & Schneider, 2009). Parts of the examination can even be corrected semi-automatically. In programming courses, for example, a set of unit tests can be used to determine whether a student's code fulfils all the requirements demanded by the examination. Only if some of these tests fail, the corrector has to have a deeper look into the student's exam. Additionally, also the effort for correcting the other parts of the examination is lowered, because the readability is clearly improved in comparison to handwritten examinations.

By providing domain-specific tools, also the proficiency level of the examinations can be increased remarkably. Considering Krathwohl's revised version of Bloom's Taxonomy of Educational Objectives (Krathwohl, 2002), assessing the more complex levels of the taxonomy, like Evaluate and Create, can be achieved in a more realistic fashion, because the domain-specific tools can take care of the lower levels of the taxonomy, so that the students can focus on the higher levels. In programming courses, the integrated development environment for example provides auto completion; therefore, the students do not need to remember every keyword of a programming language.

3. GOALS

The main goal of the previously mentioned framework for e-Assessment is to provide a solution for common issues related to e-Assessment. Therefore, this framework could potentially boost the implementation of e-Assessment at institutes of higher education. In order to possibly achieve this main goal, two sub goals have been identified that have to be fulfilled. First, the reservations against e-Assessment have to be eliminated and second a solution for financial issues has to be found.

Since most students nowadays already possess own devices that are suitable for e-Assessment (Dahlstrom, Brooks, Grajek, & Reeves, 2015) (Poll, 2015) (Willige, 2016), Bring Your Own Device (BYOD) is a potential solution to the financial issues. By implementing BYOD, the institutes of higher education would not have to maintain a full-blown IT infrastructure including servers and workstations. Instead, maintaining a server infrastructure would be sufficient, because the students would bring their own workstations. Therefore, we chose to make BYOD a key element of the e-Assessment framework.

When considering BYOD as key element of the framework, the fairness and reliability of e-Assessment get even more important, because the students' devices are not per se under the control of the examiners. Therefore, we consider it very important that the framework provides a comprehensible reliability in order to be able to reduce reservations against e-Assessment. Hence, we plan to release the framework under an open source license, once the research project is finished. That enables everyone to examine the software in detail and therefore helps to build trust, as studies suggest (Boulanger, 2005) (Miller, et al., 1995). Furthermore, it allows building a community that helps to maintain and improve the software, for example by reporting bugs or design flaws. For the same reason, we decided to use the version control system GIT as storage backend for storing the student's results: it is open source and well tested and maintained. Additionally, GIT provides a versioning of the submitted data and therefore enables an examiner to reconstruct the steps taken by a student while solving an assignment.

Beyond making the framework open source in order to build trust, the data that is processed during an examination has to be handle in a trustworthy way to further support the acceptance of e-Assessment. That means especially that the students' results have to be stored safely. Hence, it must be ensured that the results cannot be manipulated after the students have handed in and, additionally, each set of results has to be clearly relatable to a particular student (Dahinden, 2014). The usage of BYOD allows us to adapt the concept presented by Dahinden, because the students work on their own devices, i.e. on a *trusted platform*. Therefore, we can utilize cryptographic methods that do not have to rely on temporary key pairs generated for an examination, but can work with key pairs that are certified by a certificate authority, for example the DFN-PKI (DFN-PKI, 2016). That would not be possible on workstations in a PC pool, because these computers are not under the control of the students. Therefore, these systems can be regarded as *untrusted platforms* from the students' perspective.

Another issue that has to be dealt with, especially in a BYOD context, is the equality of treatment, i.e. that every student has to have the same chances of performing well in the examination as every other student. Besides being an ethical guideline that should be obeyed by examiners, it can be mandatory by law. In Germany, for example, an equality of treatment is enforced by Article 3 of the Basic Law for the Federal Republic of Germany. In the worst case, the students' devices are all different from each other, therefore it is virtually impossible to have an equality of treatment in terms of hardware. It is, however, possible to design the e-Assessment framework in a way that deals with this issue. Hence, we based the design of the e-Assessment framework on a client-server architecture. For the assessment client, which will be executed on the students' devices, we chose to implement it as a light-weight web application. Therefore, every device that is capable of running a web browser can be used throughout an examination. Any device whose processing capabilities exceed these requirements does not have an advantage.

4. RELATED RESEARCH

E-Assessment at institutes of higher education is clearly not a new phenomenon, despite still a recent one. There are several ways how e-Assessment is carried out at the moment. These spread from the usage of learning management systems (Michel, Goertz, Radomski, Fritsch, & Baschour, 2015) and their built-in possibilities, like multiple-choice questions or free text assignments, up to the utilization of special software, for example the OPS software at RWTH Aachen University (Janßen, et al., 2014).

And also BYOD for examinations at institutes of higher education is not a new phenomenon. It is already used at several institutes of higher education around the globe (Küppers & Schroeder, 2016).

In their article Brauckmann et al. describe how certificate authorities (CAs) try to standardize documentation of certificate policies. They show the importance of standardized policies. Certificate policies are mostly documents of 90 pages that, among other things, describe how security of certificates is organized and how certificate requestors authenticate. They furthermore note that common CAs formulate their policies quite differently and users should review them individually before basing processes on their certificates. (Brauckmann & Gröper, 2013).

Ubiquitous access and programmable interfaces (APIs) are becoming more important as the number of smart devices and data intensive applications rises: Not only in context of e-learning but also as parts of every users' daily routines. The Horizon report, one of the most regarded studies concerning the development of education lists Mobile Learning, Adaptive Learning Technologies and Next Generation Learning Management Systems among the important developments currently faced in higher education (Adams Becker, et al., 2017). To meet the future challenges universities approach interfaces, allowing integration of existing systems into new applications for students and employees. The works of Mincer-Daszkiewicz and Barata et al. show two practical examples of APIs in the field of university administration (Mincer-Daszkiewicz, 2014) (Barata, Silva, Martinho, Cruz, & Guerra e Silva, 2014). The process oriented architecture presented by Politze et al. generalizes for several personalized eLearning applications but aims to cover more university processes (Politze, Schaffert, & Decker, 2016).

In terms of software development, recent process supporting applications focus on small building blocks that feature integration and loose coupling. Micro service architectures as proposed by Namiot et al. reduce dependencies in the software development process often found in former monolithic applications (Namiot & Sneps-Sneppe, 2014). Virtualization allows separating these micro services from one another on the same hardware platforms. However Schleicher et al. show that virtualization and cloud environments pose additional dependencies and different requirements to the software development process and the deployed software (Schleicher, Vogler, Inzinger, & Dustdar, 2015).

5. IMPLEMENTATION

For the implementation of the assessment client we utilized the electron framework (GitHub, 2017), which itself is based on the NodeJS framework (Node.js Foundation, 2017). Thus, the client fulfills our design goal to be a light-weight web application, because the needed runtime environment can be considered equivalent to a web browser. Furthermore, the electron framework provides support for the three major platforms for mobile computers, Windows, Linux and MacOS. We plan to support also ChromeOS, Android and iOS eventually, which was another reason for the implementation of the client as web application. Therefore, no group of students has a disadvantage by having a not-supported operating system installed on their devices. Figure 2 shows a screenshot of the assessment client, which has loaded a programming assignment.

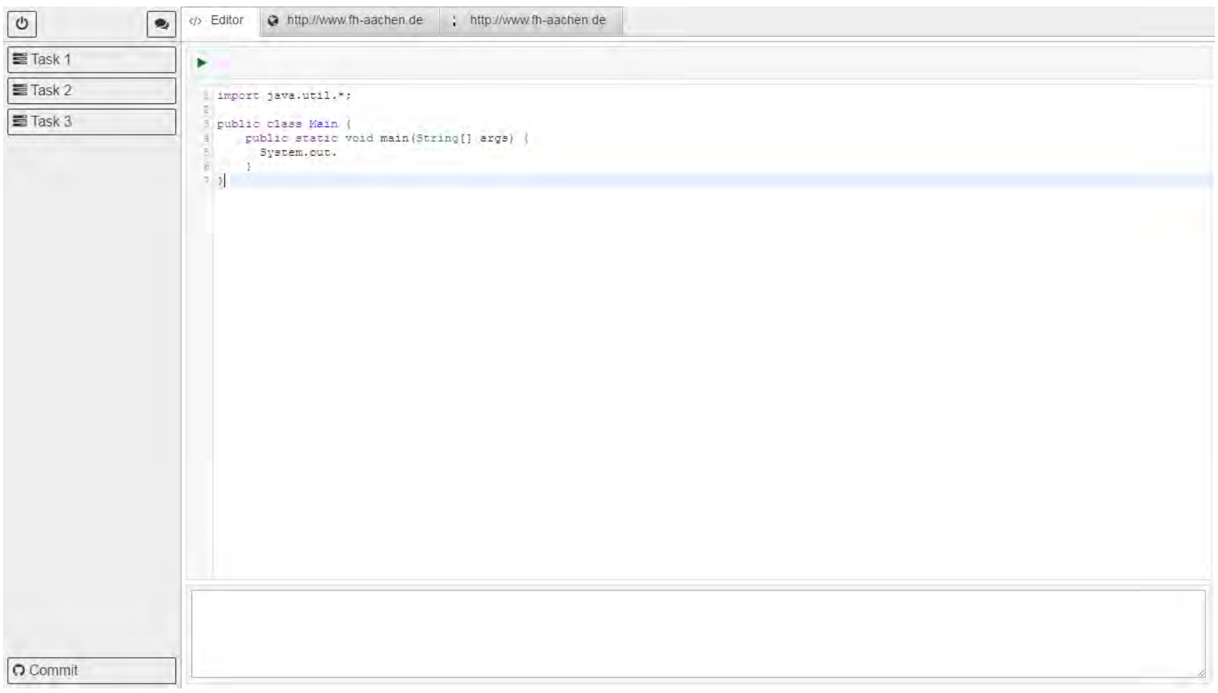

Figure 2: Screenshot of the assessment client.

The implementation is designed in a modular fashion (see Figure 3), which allows to easily extend the framework later on. Therefore, it is also possible to use another tool than GIT as storage backend for saving the students' results. Additionally, it is possible to introduce new types of assignments or to extend existing ones.

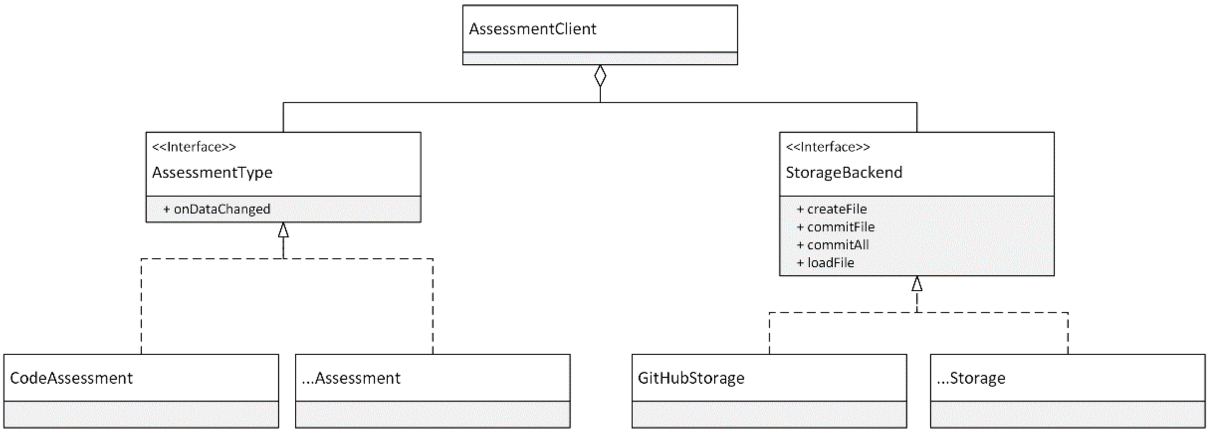

Figure 3: Modular architecture of the assessment client.

For a proof-of-concept we decided to use GitHub (GitHub, 2017) as storage backend. Therefore, we could use existing infrastructure and concentrate on the implementation of the prototype. To interact with the GitHub server, we a publicly available API that GitHub provides. This API is based on REST (representational state transfer), which is a programming paradigm for distributed systems, for example webservices (Fielding & Taylor, 2002). Due to the modular architecture, as already mentioned, it would be possible to use other services as storage backend, for example local instances of GitLab (GitLab Inc., 2017) at the institute of higher education.

In order to make the students' results relatable to a particular student, each change on the storage backend is signed with the student's private key. In case of GitHub, that means that every commit is signed. The built-in crypto modules of NodeJS were used to compute the signatures.

When the assessment client starts, it loads a configuration from the assessment server, which contains all information about the assignments. Each assignment is related to a specific file on the storage backend. If that file already exists on the storage backend, the assessment client loads that file and makes the contents available to the student. That enables the examiner to provide the students with a prepared skeleton for an assignment. If the file does not exist on the storage backend, an empty file is created for the student to work with.

The assessment server implements of two partial processes one for the Registration for the assessment and one the assessment itself. In the first, the student has to register with a certificate and therefore shows that he or she has access to the corresponding private key. The latter then secures the assessment itself. Both partial processes and other functionalities of the assessment server use also a micro service pattern to offer small, independent functionalities for different steps in the process. During the assessment, the server uses certificates from the DFN-PKI to authenticate the students. This complies on the one hand with the intended use of these certificates as documented in the certificate policy. Furthermore, the certificate policy assures that certificate authorities check ID documents when issuing a certificate (DFN-PKI, 2016).

Before the assessment, the teacher defines the students that should take part. As shown in Figure 2, the assessment server then invites unknown students to submit their certificate. If necessary, this step repeats in regular intervals until all students have registered with a certificate that expires after the date of the assessment. Students may register either by responding via a signed email or by following a link in their web browser. In the first case, the server parses the signature of the email in PKCS#7 format and extracts the contained certificate. Whereas in the latter case the web browser authenticates the user via a TLS client certificate in X.509 format (Kaur & Kaur, 2012). In either case, the server validates the certificates against the DFN-PKI infrastructure and then stores valid certificates in a key database. This database allows at later steps in the process to get easy access to students' public keys. To increase the reusability of stored certificates the certificate store extracts some metadata like validity dates, fingerprint and the public key in PEM format and saves them along with the certificate.

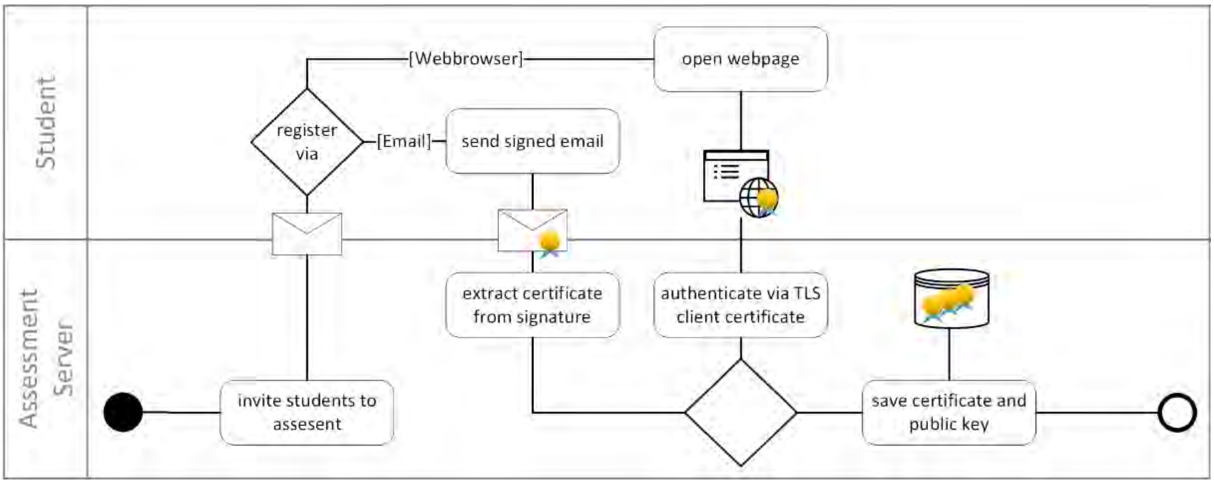

Figure 4: Partial process for assessment registration.

During the assessment, the student again authenticates with the client certificate via TLS. This time however the student uses the assessment client instead of a web browser. As Figure 5 shows, the client then tries to download the configuration for the current assessment. Upon receiving the configuration request, the assessment server validates the certificate against the certificates in its database. For each student the server creates a storage space on a compatible storage backend. Credentials needed to access the storage are stored in the configuration and then sent to the client. Furthermore, the configuration includes the task description for the assessment. With this information provided, the student can now use the client to conduct the assessment.

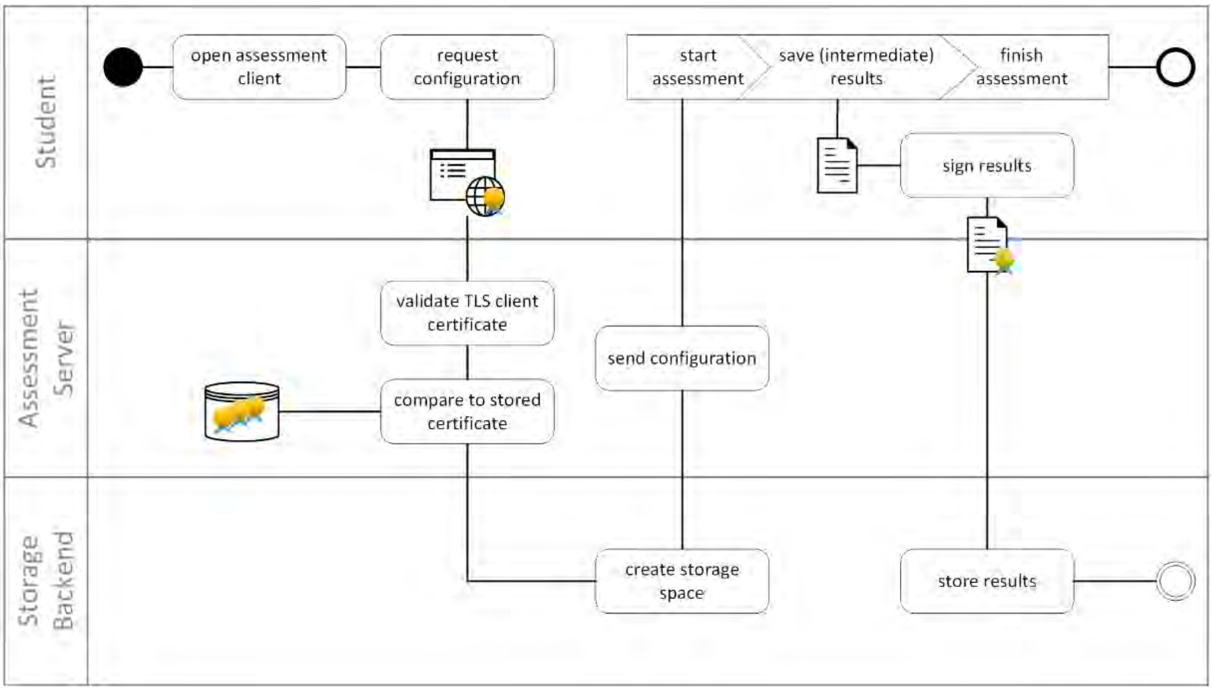

Figure 5: Partial process for taking the exam.

6. LESSONS LEARNED

During the implementation of the prototype, we noticed that the GitHub API does not have support for the GIT-native mechanism of singing GIT commits. Therefore, we decided to append the signature of the commit to the particular commit message.

Authentication using TLS client certificates only works if the server also utilizes HTTPS. While in a production environment, there is no excuse for not using HTTPS, existing development environments mostly did not offer TLS out of the box and needed configuration updates with certificates even for local testing. Opposed to the other web technologies used (IMAP, HTTP, REST), the implementation of certificate parser was complicated, libraries, like node-forge (Digital Bazaar, Inc., 2017), often do not cover full stack of parsing and interpreting different formats, certificate validation and newest algorithms.

Micro service architectures allow flexible interchange of components and easy extensibility of the system. Furthermore, they allow integration of developed services into central infrastructures more easily.

7. FUTURE CHALLENGES

Quite recently, the SHA1 hash algorithm, which is internally used by GIT, has been broken. Stevens et al. state the following regarding the affection of GIT:

"GIT strongly relies on SHA-1 for the identification and integrity checking of all file objects and commits. It is essentially possible to create two GIT repositories with the same head commit hash and different contents, say a benign source code and a backdoored one. An attacker could potentially selectively serve either repository to targeted users. This will require attackers to compute their own collision." (Stevens, Bursztein, Karpman, Albertini, & Markov, 2017)

According to that statement, the vulnerability of SHA-1 would enable an examiner to alter the contents of a student's repository after the examination. However, since the students sign their commits with their private key, the tampered repository would not contain correctly signed commits. Therefore, the vulnerability for our scenario is negligible. Additionally, since GIT is a well maintained open source project, this issue is akin to be fixed in the near future.

The DFN-PKI maintains already a public certificate directory. This could be used later on. At the moment, however, this directory has two pitfalls. First, it does not validate that a student still has access to the private key. Since the students have to use their private key in order to work with our approach, we can ensure that the student has access to it. Second, publishing one's certificate into the directory is optional, therefore students may not be in the directory, even if they have a certificate. If these issue could be resolved, due to the micro service architecture, the module for the certificate database could simply be replaced without affecting the rest of the framework.

As already mentioned in the previous section, certificate libraries were quite limited. Currently, the library used allows to parse certificates in various formats, however, it only supports RSA and not ECC. Since ECC is not as common as RSA, we still decided to use that library in order to handle the different types of certificates without problems. Finding a library that also supports ECC would be desirable.

In order to make BYOD reliable for e-Assessment, the measures presented in this paper are important parts. However, more issues have to be considered. For example, a lockdown mechanism has to be implemented, which prevents students during the assessment from unauthorized actions. These actions include, for example, starting additional software or accessing online resources.

Quite recently, the German Stifterverband granted funding to support further research of BYOD and e-Assessment (Stifterverband, 2016). Therefore, we hope that we will indeed be able to build a community, that helps to extend and improve the e-Assessment framework.

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thermoE^{int}: building e-assessment content for the integration and success of international students in STEM fields

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Keywords
thermoE, thermoE^{int}, e-assessment, e-learning, thermodynamics, student success, STEM fields, ONYX

1. ABSTRACT

The project thermoE^{int} aims to help the integration and success of international students in the field of Thermodynamics through the creation of a comprehensive relation of English e-assessments. In this work, the utilized methodology and workflows for the implementation of the online content in STEM fields are introduced. They are based on the determination of didactic and technical requirements for the online content after analyzing the gathered data obtained from educational staff experience, previous e-learning projects and students' feedback. With the help of the software and learning management service of ONYX and OPAL, a set of proposed solutions are introduced. In the same context, to ensure the quality of the online teaching material, a continuous improvement workflow is proposed on a year-to-year basis.

2. INTRODUCTION

During the last years, the development of e-learning content has been proved to be a very practical tool to enhance existing learning options for students and workers. This is due to the fact that e-learning can be used anytime and anywhere. At the universities, this versatility simplifies the process to reach a wider number of students, especially, those who may have difficulties understanding the lecture. That is particularly true with foreign students as the language is a great barrier to overcome. In order to improve the integration and success rate of foreign students at the Technical University Dresden, the project thermoE^{int} (thermodynamic e-assessments for international students), which is in the testing phase, aims to offer English electronic online exercises (e-assessments) in the fundamental subject of Technical Thermodynamics.

Another particular aspect of this project is the development of exercises for science, technology, engineering, and mathematics (STEM) subjects. In this field, the technical and didactic requirements differ from those in social sciences, where most studies and methodologies have been studied (Breitkopf, Kretzschmar, & Köhler, 2015). As a consequence, contributions guiding the path to the successful implementation of e-learning activities in the STEM field are required.

In this contribution, our methodology for building a comprehensive didactic relation of e-assessments will be introduced. The implementation of a dynamic continuous improvement system through feedback will be also discussed.

3. METHODOLOGY FOR THE CREATION OF E-ASSESSMENTS

The methodology to establish the didactic and technical requirements for the creation of online e-assessments is based on the experience. Teaching is a field which cannot be evaluated only with quantitative data. Qualitative data is crucial to understand the needs of the students and the issues that they have. The educational staff provides the most valuable feedback and ideas as they are in direct contact with the students. Members of the staff have to deal with their problems on a daily basis.

Before establishing the objectives and starting to build the exercises, it is necessary to gather experiences and opinions to determine which issues must be taken into account and transform them into the needed didactic and technical requirements. Figure 1 represents the flow diagram of the process.

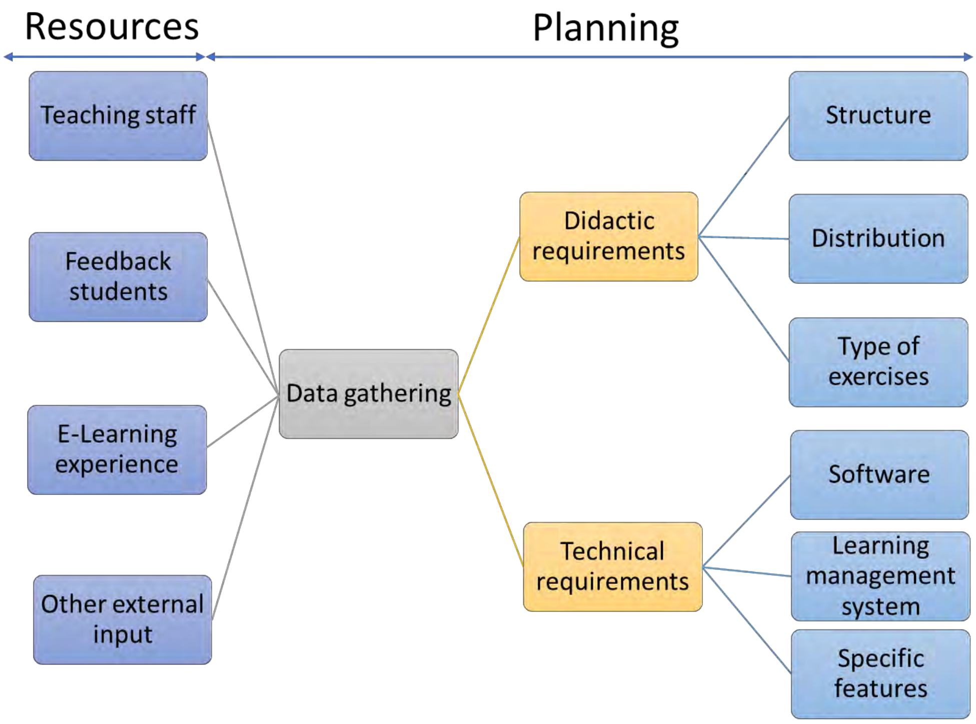


Figure 1. Schematic workflow for planning the e-assessments

The experience is the key factor for the success when implementing any kind of teaching strategies. As a consequence, the foremost source of data gathering comes from the teaching staff. Qualitative data are gathered through interviews and talks with the Professor responsible of the subject, the seminar supervisors, tutors and other chair members. From the Professor, it is possible to learn the structure of the subject and the questions he/she had from the students after the lecture. This experience is then used for the development of conceptual exercises which are meant to build the theoretical background of the subject. From tutors and seminar supervisors, data about current students' solving skills can be acquired and used for developing practical online exercises.

The students' feedback is also of key importance. This feedback can come directly from them in electronic or personal form. The personal form would come by talking directly with them. The second option would be to get their feedback electronically if an e-learning system was already developed. In the case of this work, we had already some experience in this area. It comes from previous projects: thermoE for developing the conceptual, theoretical, and didactical framework for building thermodynamic e-assessments (Freudenreich, Breitkopf, & Kretzschmar, 2016; Breitkopf, Kretzschmar, & Köhler, 2015; Freudenreich, Lorenz, Pachtmann, Breitkopf, Kretzschmar, & Köhler, 2014), thermoSA for the practical implementation of thermodynamic self-assessments (Breitkopf, 2015), and SPAts for the implementation of self-/peer-assessments in thermodynamics and supply chain management (Freudenreich & Lorentz, 2015). After the development of those projects, e-assessments have been used every year by about 500-600 students. Those e-assessments were implemented within the frame of the subject "Technical Thermodynamics". This fact gives us currently about 10-50 feedbacks/comments from students in every online test which are very beneficial for the implementation of new exercises as well as to improve the existing ones.

The last source of information, which was gathered, is the input gained from external resources such as literature, conferences, experiences from other departments, questionnaires and surveys. In this context, as a prerequisite for the development of thermoE^{int}, 22 foreign students from different subjects took part in a questionnaire to know what they expected from the e-learning platform, which their skills were and their suggestions. We found out that 85% of the students who took part in the questionnaire spend the same or more time in self-study as in lectures/seminars, 62% use internet resources frequently for learning and between 60-70% of the participants use internet for downloading subject's material. This quantitative data show that most students are acquainted with online resources and it is easier to approach them using online e-assessments as learning tool.

Once the data was gathered, problems, requirements, and solutions were discussed. Those requirements are classified into two categories: didactic requirements and technical requirements.

3.1. Didactic requirements

The main objective of a learning strategy is to overcome the forgetting curve (Figure 2). The green curve shows the retention during a lecture. Some hours after that, in absence of a review of the content of the lecture, the retention decreases following the red curve (Ebbinghaus, 1913; Murre & Dros, 2015). E-assessments and seminars help to minimize the forgetting curve, refreshing the acquired knowledge and following the orange curve. As the number of repetitions increases, the probability of forgetting the lecture content decreases.

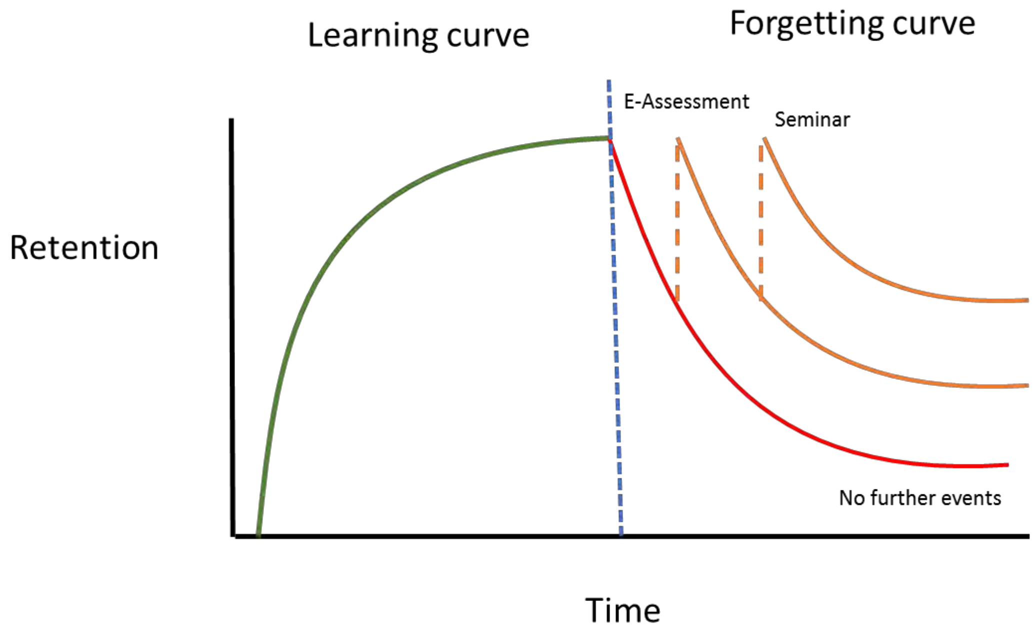


Figure 2. Learning and forgetting curve

The most important step to overcome the forgetting curve is to integrate the tests within the lecture framework. That means to divide and distribute all tests per lecture week or lecture session so that the students can do exercises related with the content of the last lecture. In our project, there were twelve lecture weeks so twelve e-assessments were built. They were available on the same day of the corresponding lecture and the students had access to the test during the whole week until the next lecture session. The number of trials was limited to two in order to encourage a learning effort from the students and avoid "trial and error" techniques.

The exercises had an increasing difficulty level within each test. Easier tasks were placed first and key concepts were shown for its utilization in subsequent tasks within a more complicated context. The distribution of different task types is also important. We divided the tasks into two: conceptual tasks and solving skills tasks. Conceptual tasks are meant to make the student learn the concepts and the theory taught in the lecture. The second objective of these tasks is to get the student acquainted to the learning material, in other words, to force the student to look for the equations that he/she needs and to learn where to find them. In our case, text gap exercises were included where the student had to write the number of an equation from the formulary/subject's manuscript or the page where it is located thus increasing the subject's material management skills. Solving skills tasks are mathematical exercises where the students must solve a problem numerically. In a technical degree, most of the exercises belong to this classification. Solving skills exercises promote reasoning, logic and resolution skills. It is advisable to mix conceptual tasks with solving skills tasks as it helps with the motivation of the students due to the variability of exercises preventing long term boredom. The percentage of conceptual exercises must be higher in the first E-Assessments of the semester to found the basis of the understanding of the subject and to increase the handling ability of the solution tools such as equations, tables, etc. The balance must be gradually changed to a more solving skills based exercises as the course approaches the last lecture weeks. In the project thermoE^{int}, the first test was built with an 86% of short conceptual tasks (out of 29 tasks) while, in the last test, the amount of conceptual task was reduced to a 12.5% (out of 24 tasks). This is done to favor the preparation for the exam which is more practical oriented. The exercises must follow a logical resolution structure so that the students learn how to solve typical exercise types step by step.

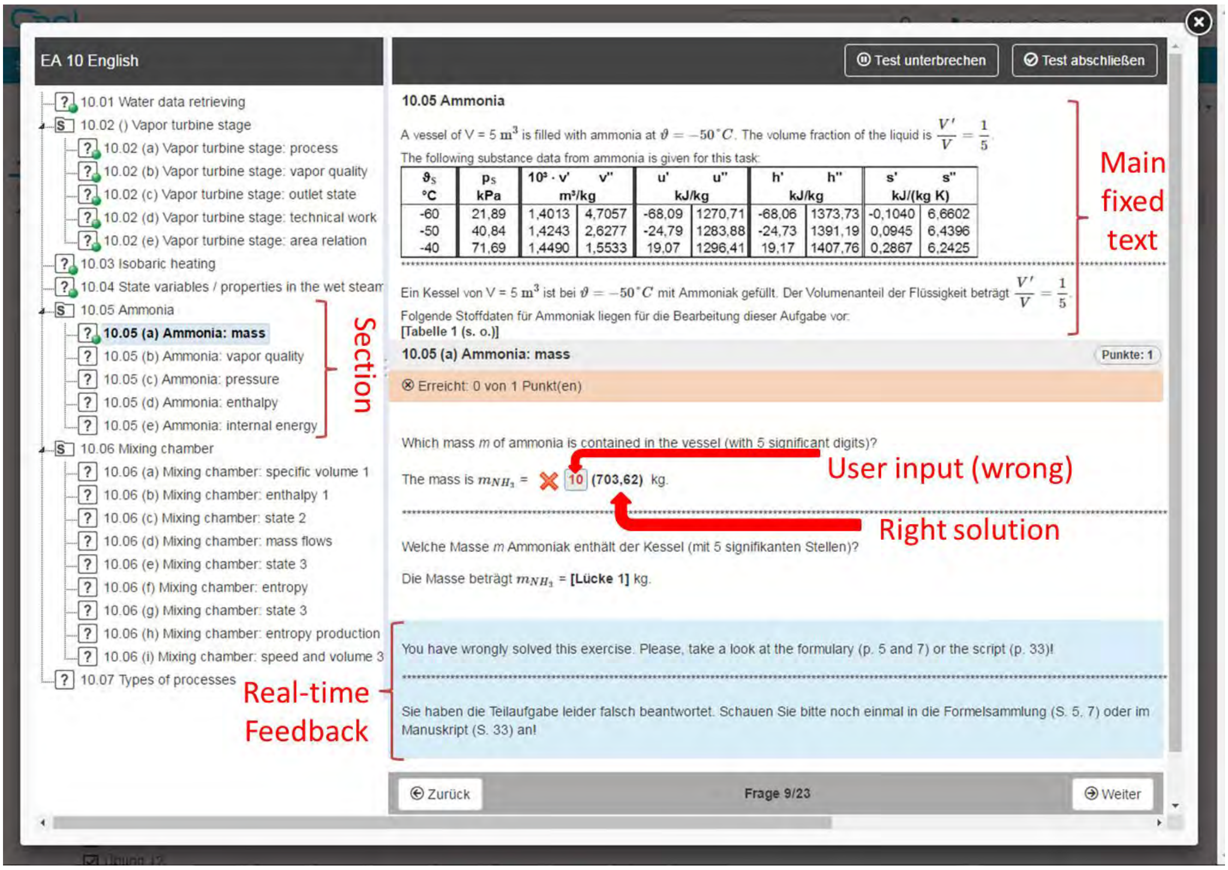
Last and foremost didactic requirement in our project was to help foreign students to get acquainted to the subject content. Let us introduce some quantitative data from the international students' survey first. 52% of the students that participated in the survey had difficulties with the language during their studies, while the 71% affirm that they have a greater barrier to overcome when studying due to the language. The first idea to support international students was to offer English-only tests. However, the real obstacle is to translate the knowledge learnt in German to use it in English e-assessments and vice versa. The found solution was to translate the most important tasks to show the correlation between German and English technical terms and prepare them to use both interchangeably.

For student's preparation and their quick adaptation to the online e-assessments, a tutorial was also developed so that they could understand how the overall system works. According with their comments, the tutorial has been a much appreciated resource by the students.

3.2. Technical requirements

Technical requirements are heavily dependent on the software, the learning management system or platform, and the features they offer. In thermoE^{int}, the requirement of the software is to have plenty of options for exercise customization, while the learning management system (lms) had to be easy to use, transparent to the user and it had to reach the students easily. For these reasons, the chosen software for exercise development was ONYX Editor (Benutzerhandbuch ONYX Testsuite, 2016) as it gives plenty of options and it is very well integrated in OPAL, a lms completely integrated in the Universities of Saxony. Students of our university are already familiarized with OPAL so it is natural for them to use it for every subject. Furthermore, ONYX provides a lot of tools for improving the e-learning experience which allows us to create the e-assessment content.

One of the technical requirements was that the students must learn the logical structure to solve the practical questions. Hence it is important to offer a step by step solution of the exercise so that the students get acquainted with which step comes first and which the solution procedure is. In order to implement this, the ability of ONYX to create exercises with sections was utilized. Section based exercises are those which have different sub-tasks and each sub task is shown sequentially but not concurrently, in other words, sub-task b is not shown until sub-task a is completed. All subtasks share the main text with the formulation of the overall exercise with the initial data so that it is directly accessible while being in the corresponding subtask (see Figure 3). This simplifies the user experience as they do not have to go back and forth to get the initial data of the exercise or to read again the main formulation of the exercise. The second reason to use this structure is to be able to avoid consequential errors. Every subtask can be evaluated before going to the subsequent one. By evaluating the solution, if wrong, the students obtain the right solution and they can use this value in the following subtasks (see Figure 3). In other implementations, that is not possible to do so a mistake in the beginning of the exercise would lead to wrong values in the rest of the exercises after all the time the students spent in performing all the calculations. With the presented method, motivation issues due to consequential errors are minimized and the logical resolution steps are forced to be utilized.



ϑ_s °C	p_s kPa	$10^3 \cdot v'$ m³/kg	v''	u' kJ/kg	u''	h' kJ/kg	h''	s' kJ/(kg K)	s''
-60	21,89	1,4013	4,7057	-68,09	1270,71	-68,06	1373,73	-0,1040	6,6602
-50	40,84	1,4243	2,6277	-24,79	1283,88	-24,73	1391,19	0,0945	6,4396
-40	71,69	1,4490	1,5533	19,07	1296,41	19,17	1407,76	0,2867	6,2425

Figure 3. Capture of one test after a wrong input

Real time feedback is also an advisable feature to have along the section structure as shown in Figure 3. ONYX Editor allows the definition of a text showing a sub-task dependent feedback for the students. If the students wrongly solved a given sub-task, a text appears with hints to learn how to correctly solve that sub-task, for example, by giving the subject's script page, the formulary page, a reference book or, if the sub-task is especially difficult, the complete resolution process. With this methodology, the students can actively look for the solution, increasing the learning experience, and learn immediately what they did wrong. They also learn how to use the provided learning material more efficiently.

In STEM subjects, the students must do many calculation exercises to improve their solving skills. This can be trained with e-assessments. However, every student often has a different solution of a given task due to the use of different decimal numbers or slightly different parameters. To avoid that, tolerances must be implemented. In our project thermoE^{int}, a common used relative tolerance is between 1% and 5% after analyzing the impact of a solution at the extreme sides of the tolerance. The chosen tolerance should also prevent wrong solution procedures to be wrongly taken as right. Tolerance in text gaps were also introduced so that one misspelled letter is not taken as wrong.

As in the didactic section, a variety of exercise types also avoids boredom and increases the motivation of the students. It is recommended to mix exercise types. In the project, the following types of exercises were implemented (ONYX Aufgabentypen, 2016):

- Choice exercises: single and multiple choice options
- Text gaps: the student must fill the gap with the correct solution, different solutions must be defined beforehand

- Drag and Drop exercises: two columns where the student must match two concepts
- Matrix exercise: two-dimensional matrix where the student must select which relations are right
- Order exercise: order different given statements in a requested order
- Hotspot exercise: click the right area of a diagram or picture
- “False text” exercise: the student must find out which terms are wrong
- Textbox exercise: a text where there are gaps, where the student has different options from a drop-down list
- Numerical input: gaps where the students must write the numerical solution
- Calculation exercises: similar as the numerical input but with random initial parameters
- Equation comparison: the student must write the requested algebraic expression

The duration of each test was planned to be between one and two hours for a total amount of 12 tests (12 lecture weeks) with 116 online exercises. They have the feature to stop the test at any time and resume the test another day so the students can freely choose when and where to do the weekly scheduled e-assessments. The higher the number of times they resume the test and make a couple of exercises, the better the forgetting curve is overcome (see Figure 2). It is important to encourage the students not to do all the exercises at once and distribute the time spent in e-assessments along the lecture week.

Finally, a feedback survey was placed after each e-assessment in order to gain knowledge about the behavior of the test, potential issues and satisfaction of the students.

4. DYNAMIC AND CONTINUOUS IMPROVEMENT THROUGH FEEDBACK

Once the first functional version of the e-assessments is built and tested, new revisions must be performed after every year to perfect the e-assessment content (see Figure 4). Two kinds of modifications can be distinguished according to the timeline when they are performed: changes during the semester; and changes between docent years.

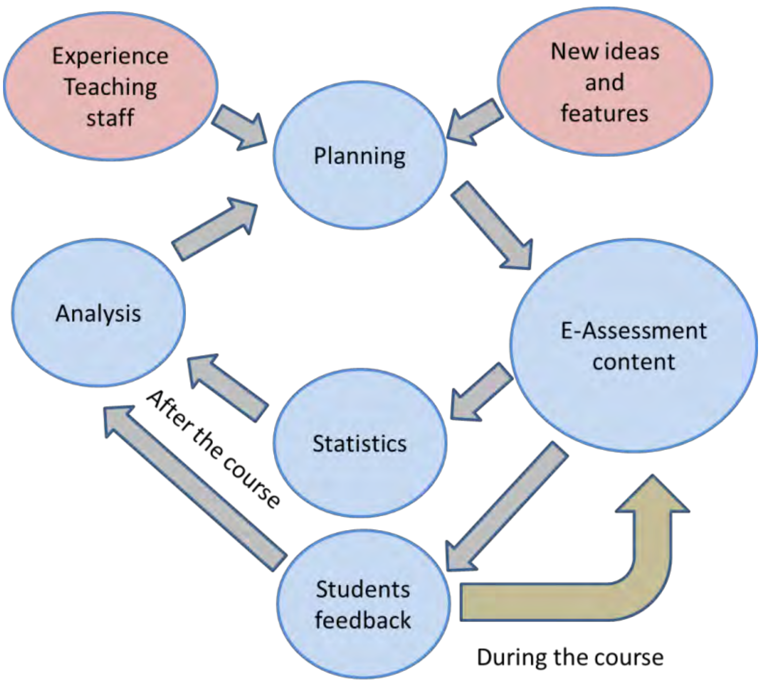


Figure 4. Workflow diagram for the continuous improvement of the online content on year-to-year basis

For the dynamic improvement during the semester, a feedback survey is implemented after every e-assessment. The students can anonymously give their opinion about the duration, suitability and difficulty of the test. Additionally, they can also give feedback about which issues they had and write a free text about suggestions for improvements and other comments. This information can be used to make "on the fly" changes if they do not affect the outcome of the exercise/task. It is advisable to read the initial feedbacks a short period after unlocking the tests to check if everything is working properly and to prepare changes for subsequent e-Assessments in case it is necessary.

For the improvements of the e-assessment from one docent year to the next, there are two sources of information: analysis of the students' feedbacks after every e-assessment and statistical data. Our learning management system, based on OPAL and ONYX, can register statistical data such as the percentage of right/wrong answered tasks, the summary of the most written values in numerical exercises, and the overall pass/fail rate of each e-assessment. With these data, it is possible to analyze possible deviations of the average results and to determine which exercises are more problematic. This allows the docent staff to perform the corresponding modifications for a more consistent and improved collection of e-assessments and a better teaching quality. During this improvement cycle it is also possible to implement new ideas and/or features.

The project thermoE^{int} is currently in the testing phase. While the introduced workflows are already in use, the analysis of the outcome of the project will be performed at the end of the docent year 2016/2017.

5. SUMMARY AND CONCLUSION

In the project thermoE^{int}, the methodology employed for building a comprehensive relation of online tests or e-assessments for foreign students has been introduced for the field of thermodynamics as a pilot project for other STEM fields.

The foundations of the project have been built around the experience of the teaching staff, previous e-learning projects, and students' feedback. With the analysis of the gathered data, didactic and technical requirements for the e-assessments have been developed and then translated into online content with the selected tools: ONYX and OPAL. This work deals with the typical issues in STEM fields and provides a practical view of how to overcome them.

Finally, a workflow for the implementation of a continuous improvement cycle for e-assessment content is shown to increase the teaching quality of the online content on a year-to-year basis. After the first currently running implementation, the results will be analyzed and the effectiveness of such methodology will be tested.

6. ACKNOWLEDGEMENTS

We would like to thank the European social fonds (ESF) and the European Union for the financial support of the project thermoE^{int}, project number: 100251113.

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LESSONS FROM PROJECTS FUNDED BY NORWEGIAN AGENCY FOR DIGITAL LEARNING IN HIGHER EDUCATION 2010-2014

Hilde Gaard & Sofie Osland, Norwegian Agency for Digital Learning in Higher Education

Norwegian Agency for Digital Learning in Higher Education funds development projects in the use of learning technology in Norwegian Higher Education. We are in the process of completing a report on the most important experience gained from projects we have funded in the period 2010-2014. We are keen to present some of this knowledge during EUNIS 2017.

Who are we?
Norwegian Agency for Digital Learning in Higher Education is a national agency, reporting to the Norwegian Ministry of Education and Research. It is intended to be a driving force for promoting the development of flexible education and pedagogic use of ICT, and working to enhance and develop cooperation between higher education and the work life.

The guidance for project funds in the period 2010-2014 emphasizes that the projects we funded should contribute to relevant, high-quality education being made available to students regardless of time, place and life circumstances. This should be done by developing flexible educational offers, supported by technology and open digital learning resources. The projects are also expected to share and disseminate knowledge gained through the projects with others in the university and university college sector and other relevant sectors. A key priority area was collaborative projects between higher education and the work life.

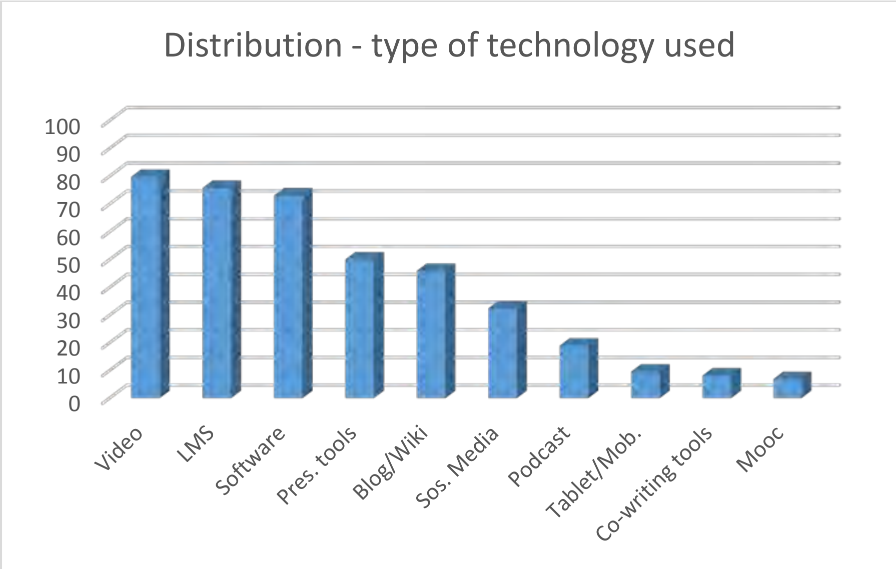
In the report we consider experience gained from the projects under the following topics:

- The educational offers developed or further developed by the projects (net-based, mixed or campus courses)
- Digital learning resources
- Are the digital learning resources shared with others and re-used?
- Pedagogic development work (including design of studies, student-active forms of learning, use of the workplace as learning arena).
- Are the projects contributing to better access to education for groups who traditionally do not take part in higher education?
- Collaboration between educational institutions.
- Collaboration between educational institutions and the work life.
- Criteria for success
- Challenges

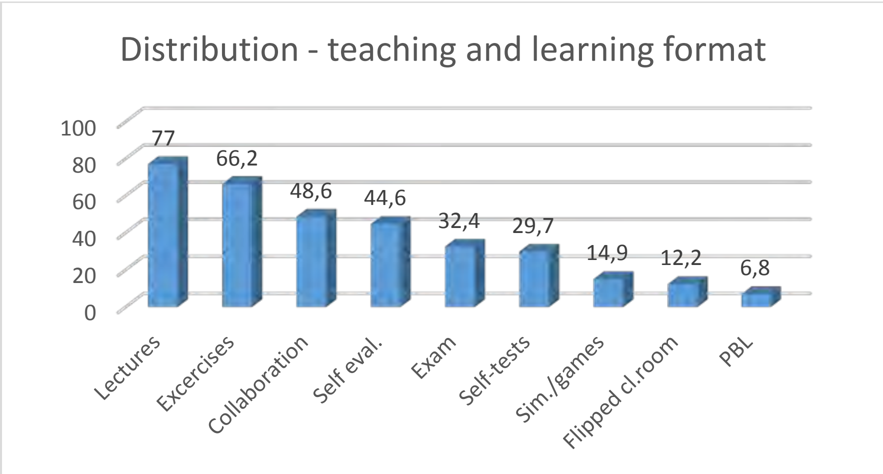
Norwegian Agency for Digital Learning in Higher Education summarize and analyse the reports in view of best possible knowledge development and dissemination of results. The goal is to find out what has been the learning outcome from the projects.

There is a great variety and diversity in the lessons that can be extracted from the project experiences. Some of the reports emphasize the tool they have tested, others underlines the study design and others the organization of the project. We experience good cooperation within the project is particularly important. Including the gathering of necessary expertise in the project group. The use of digital tools gives good lessons, firstly in terms of being useful and raising the quality of the study, but also that it contributes to competence raising and innovation.

Some examples of areas of findings:



Distribution of projects by type of technology used. Percentage. (Credit Ida Grepperud)



Distribution of projects using various teaching and learning formats. Percentage. (Credit Ida Grepperud)

The need for learning activities to involve binding commitment is a topic raised by many of the projects. Many stress that the students have to be kept actively involved and urged to keep going. Many of the projects have experienced that the students do not participate as actively in e-learning activities as hoped for and anticipated if it`s voluntary. The students are often less active than expected when it comes to writing and sharing inputs (for example blogs) and taking part in discussion groups. Many of the projects have found that they need to hold regular on-line meetings and set frequent exercises in order to keep the students active.

ICT-supported learning

Digital learning resources often give students the opportunity to work more interactively. They receive more resources and several projects stress that digital learning resources give more freedom of choice of learning methods.

In one of the projects, the students produce short videos where they present subject matter. The project describes how video production influences the students’ learning:

> *It involves the students themselves in having to plan and structure the subject matter within a tight, confined framework in the form of a video clip. This forces the students to think carefully through the subject matter involved.*

MOOCs
Norwegian Agency for Digital Learning in Higher Education funded the first MOOC-project in 2013, but had MOOC-like projects as early as 2011. These projects have challenged the institutions administration related to student registration and examination and the projects have contributed to map and develop solutions to problems relating to the need for flexibility and the number of students that these kind of courses have to manage.

> *This has been the first attempt with MOOC at this institution, and we have succeeded in establishing this form of online study as a potential alternative at our institution. Through this project, a collaboration has been initiated to customize administrative systems for study information, admission and exams.*

Ripple effects and changes
It can be difficult to say that single projects have caused ripple effects and changes in organizations. The projects are reporting increased digital competence in the involved academic communities and that knowledge from the projects has been transferred to other academic communities.

Some major ripple effects and changes described:
- Increased digital competence in the academic communities
- Proliferation of knowledge from projects to other professional environments
- Strengthened cooperation internally, between educational institutions and with working life
- Change of administrative procedures/routines

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Building a Digital Roadmap for greater engagement and success

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Keywords
Digital Strategy, Digital Roadmap, IT Strategy, Corporate Strategy

1. SUMMARY

In 2013 the Queensland University of Technology's IT Strategy had expired. The technology landscape was changing rapidly, and the university was increasingly aware and responsive to the transformative changes occurring in the global higher education and research sector. By the end of 2014, a compelling case for change was proposed to the IT Governance Committee, and QUT embarked on a very different strategic approach to digital leadership than it had in the past.

The presentation on QUT's Digital Roadmap describes how to build a case for change and break from past practices. The presentation outlines how leadership, engagement and placing the customer at the centre of everything you do is essential to success.

2. ABSTRACT

The defining characteristics of the Queensland University of Technology (QUT) are to produce graduates able to adapt and thrive in a changing world, and deliver impactful research that contributes to Australia's growth and competitiveness. To do this, QUT needs to be at the forefront of technology and innovation. QUT aspires to leverage and lead with digital technologies and data to drive business outcomes, that facilitate and enrich learning, teaching and research.

In 2013 QUT's IT Strategy had expired, and for nearly one year there were no plans to replace or update it. By the end of 2014, a compelling case for change was proposed to the IT Governance Committee, and QUT took a very different approach than it had in the past. It chose not to redevelop an IT strategy, but to develop a Digital Roadmap that underpinned the corporate strategy. The Digital Roadmap was highly integrated with the three spheres of university activity:

- Students, learning and teaching
- Research and innovation
- People, culture and sustainability

More than 70 senior academic, research and professional staff from across QUT were engaged in the development of Digital Roadmap in 2015. Through this wider engagement, the Digital Roadmap was aligned with, and now underpins, university plans for Real World Learning and Real World Research.

This presentation will demonstrate the criticality of broad support in the development of a Digital Roadmap; placing the customer at the centre of everything you do; how to embed ongoing support long after development; and finally the measurable outcomes one year after completion.

The objective of the presentation will be to illustrate a case study example of how leadership and engagement are at the heart of strategy development, and that success is a journey, comprising the achievement of mutual goals and continuous alignment of investment priorities in a commonly accepted direction.

3. ABOUT QUEENSLAND UNIVERSITY OF TECHNOLOGY (QUT)

QUT is a major Australian university with a global outlook and a real-world focus. The university is one of the nation's fastest growing research universities and it's courses are in high demand. It's graduates include eight Rhodes Scholars, five of these awarded in the past six years. QUT has a world ranking of 28 in the top 100 world universities under 50 years old as ranked by Times Higher Education.

The Univeristy is an ambitious and collaborative institution that seeks to equip its students and graduates with the skills they need in an increasingly disrupted and challenged world. QUT is transforming the student experience for its 47,200 students and has a staff profile of 12,900.

4. PREVAILING SITUATION

The three year IT Strategy for the university had expired in 2013, and consequently, there was no explicit IT leadership direction for how digital technologies should best be deployed to meet the strategic aspirations for the university. The university IT governance model was also being reviewed, and there were views at the time was that it was not responsive enough to innovation or in meeting new challenges.

A business case highlighting the challenges facing the university was developed in late 2014 and presented to the University's IT Governance Committee. The IT Governance committed approved the development of an innovative Digital Roadmap that would be highly aligned to the QUT Corporate Strategy (called the "Blueprint").

5. MAJOR TRENDS AND THE NEED TO TRANSFORM

Around the same time as the business case was being prepared to develop a Digital Roadmap, the university was already considering the major trends in the higer education market place, and identified a number of areas that were likely to reshape higher education.

The major trends being identified by the university were in four key areas:

- Transformative (Digital) technologies
- Amplified Expectations
- Intensified Global Competition
- Engagement and Partnerships

The impact of transformative (Digital) technologies were identified as follows:

- the ubiquitous availability of knowledge online; student learning was increasingly being informed by materials that were not developed by the university.
- the availability of new technologies that could enhance learning, and therefore potentially increase graduate outcomes.
- students own expectations of the quality and personalisation of on-line services.

- the rise of big data and analytics, and the promise that better information derived from all our data could inform better decision making.
- the granularisation of learning, and new trends such as micro credentialing that recognised student learning.
- use of technologies in driving process efficiency.

The university also recognised a level of amplified expectations arising within its community. These expectations naturally included the strategic importance of achieving a high global research standing, and the essential outcome of achieving high employabity of its graduates. However, there were increased expectations provide students with tailored experiences; managing an increasingly diverse student population; and in providing a return on investment in all its key decision making.

Other trends and challenges were present. QUT recognised the intense global competition for high calibre students, staff and funding. Asian universities were advancing rapidly; the Australian academic workforce was ageing; public funding for universities was shrinking; and research needed to focus on national priorities in order to attract scarce funding opportunities.

QUT also saw that it needed to focus more heavily around engagement and partnerships in order to adapt. It was recognised that greater University-Industry co-funding of research and increased commercial partnerships was required in order to respond to a tighting of public funding, but also to ensure high impact.

6. IT GOVERNANCE

QUT's IT Governance had served the QUT community well over the previous decade. However, the dynamic and fast changing external IT enviroment, combined with a number of internal factors, necessitated that the university focus significant effort and attention to the way in which it managed its ICT investments.

The previailing IT governance process did not structurally differentiate between initiatives of different strategic value. There was effectively one pool of funds, which was broken up by type of investment such as contract maintenance, project etc., and prioritised against the collection of proposals of various strategic values. In addition, proposals prepared by areas seeking funding took a minimum of 12 months for successful initiatives to traverse the governance approval process. This process was considered far too slow even in industries that were not facing strong competition.

The business case for the Digital Roadmap was presented as a strategic instrument that could assist the university in communicating its required digital transformations and provide the mechanism to guide future project proposals made through its IT Governance process.

7. DIGITAL ROADMAP OVERVIEW

The Digital Roadmap now sets the agenda for QUT's digital transformation that is aligned to the broader transformation occurring in learning and teaching, the elevation of research impact and outcomes, and enhances engagement across the QUT community. It is divided into three spheres of activity:

- **Students, learning and teaching**
  QUT will build digital capacities that help create an engaging, innovative, and responsive learning and teaching environment. In so doing, QUT recognises the intersection between pedagogy, technology, and the built environment.

- **Research and innovation**
  QUT will use digital technologies to transform research, enable innovation and strengthen engagement in our broad community.

- **People, culture and sustainability**
  QUT will enhance and energise its digital workplace to create an environment of collaboration and community engagement.

8. CONCLUSION

Significant issues occur when there is non-alignment of IT investment with the strategic priorities of the university which range from ineffective balancing of investment across different spending categories; an inability to gain an overall view of the return on investment of the IT portfolio and the absence of a framework to assist the university to deliver on its corporate strategic aspirations.

The benefits of the Digital Roadmap have been significant and include:

- IT investments are more tightly linked to the business strategy of the university.
- Allocation of funding is balanced between innovation, strategic and business as usual investments.
- IT Governance is underpinned by a widely accepted Digital Roadmap that is highly aligned to the digital transformations required in Learning & Teaching, Research and the Enabling services of the University.
- An enunciation of the key goals, principles and initiatives in a language understood by all parts of QUT's academic, research and professional staff and the wider QUT community.
- The completion of projects and innovations outlined in the roadmap.

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Digitalization of Higher Education from a Student's Point of View

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1. ABSTRACT

The process of digitalization challenges universities worldwide, in particular the universities' IT. Qualitative interviews with students were conducted to gather information on service requirements. Three service categories clearly dominate the students' wishes for IT support: study organization, online literature and software provision. As regards the study organization, a centralized platform granting access to all relevant information and services (e.g. schedule, exam administration, certificates, study progress, contact information) is particularly important. From the students' point of view, IT should enable them to focus on the content of their studies, provide support for organizational problems, and grant easy access to resources, such as literature and software, while at the same time require little effort.

2. BACKGROUND

University IT is challenged by the accelerated process of digitalization in higher education which, among other things, becomes manifest in a pervasive use of information technology for the support of teaching and learning (e.g. time-shifted learning via podcasts, digital materials and annotation or real-time interaction in class) (Brown-Martin & Tavakolian, 2014; Craig, 2016; Hanna, 2016; Hochschulforum Digitalisierung, 2015). This process is often referred to as a revolution (Bischof, Friedrich, Müller, Müller-Eiselt, & Stuckrad; Shark, 2015) or a shift (Biddix, Chung, & Park, 2015). The discussion is partly fueled by companies who, not least in their own interest, see a multitude of possibilities (e.g. Cisco, o.J.). Often the question of costs is focused, because a cost-cutting effect is ascribed to the digitalization at universities (Bowen, 2013). Although there are some studies focusing on the digitalization in the field of higher education, they are either very specific and their results can only be generalized to a very limited extent, or they are designed as a quantitative study and therefore allow only a very general view of the subject. A good overview of the status of digitalization is provided by the annual ECAR studies by EDUCAUSE, which focus on both the students (50,000 participants) (Dahlstrom, 2015) and the lecturers (13,000 participants) (Brooks, 2015) in the USA. Despite the lecturers' high willingness to use innovative tools in teaching and the ever-increasing technical equipment available to students, the results show that digitalization is only at an early stage of development. Other studies focus on individual subtopics of digitalization, such as the use of mobile devices and online services in university libraries, the use of apps by medical students (Briz-Ponce & Juanes-Méndez, 2015), or the use of online literature and online references for studying (Connaway, Lanclos, & Hood, 2013). An aspect that is highly important but often missed out in the discussion is how students make use of and benefit from an increasingly digitized study environment. Therefore, insights into the needs of students and their view on digitalization are required.

3. RESEARCH DESIGN

In the absence of recent studies on the digitalization at universities from a student's point of view, this study is designed as a pilot study which focuses on the following research question:

From the student's point of view, to what extent is the student lifecycle already digitized and which improvements are needed?

To identify improvement opportunities, we need to find out which university IT services are relevant to the students and how their user experience proves to be. In this context, it is also interesting to know which applications are used for study purposes that are not offered by the university, but by commercial providers. Aside from improvements of existing services, the study also aims to determine which new services the university should provide.

As recommended in the literature (Prickarz & Urbahn, 2002; Schulz, Mack, & Renn, 2012), an interview guideline was developed to structure the focus group interviews with regard to the research question. A guideline from a previous study on students' requirements concerning a web portal was used as a starting point and only content adjustments had to be made. The guideline divided the interviews into three sections: In the first part, the participants had to describe their own experiences with the use of IT during their studies, in order to reveal which aspects are already digitized and which are still processed offline. In this context, used (university or commercial) services as well as usage situations and problems were of particular interest. In addition, the participants had to suggest IT services which the university should offer to simplify their studies. In the second part, the participants had to write down and classify those of the suggested IT services which they attach particular importance to. In the third part, each participant had to prioritize the services by assigning a total of ten points and explain his decisions. A ranking list was formed from the prioritizations.

Students from various departments of Münster University were recruited using flyers, the ZIV's website and Twitter profile, and the university's Facebook group. Vouchers with a value of 25 Euro were used as incentives. Eleven students from various disciplines were selected to participate in the two focus groups. The first group was made up of students from IT-related courses such as information systems, computer sciences and mathematics, while the second group consisted of students from non-technical courses such as psychology, history, politics or chemistry. However, most participants in the second group also considered their technical affinity as above-average. The participants were between 20 and 35 years old and studying between the 1st and 11th semesters. Two participants were female. The targeted equal distribution of both genders could not be achieved due to the self-recruitment procedure. Five participants had previously studied at foreign universities and were able to contribute these experiences to the discussion. One participant was already working and studying part-time. The participants did not know each other.

The focus groups took place in a neutral meeting room on two dates within a week in January 2017. The conversations were recorded and subsequently transcribed by assistants. The transcribed interviews comprise a total of 56 pages (30,300 words). The data were cleansed and structured, and significant statements were extracted and clustered into subject areas. The participants' prioritizations of services were also grouped into thematic areas (Ruddat, 2012).

4. FINDINGS

In the following, the results of the focus group interviews will be presented.

4.1 Status Quo of Digitalization

The participants perceive the degree of digitalization of their studies very differently depending on the particular aspect of student life. When it comes to the provision of lecture materials, they report that the Moodle-based e-learning platform Learnweb is widely used and has a very good reputation. Some lecturers, however, do not use the Learnweb due to a lack of technical competence. About half of the participants still work the traditional way using paper copies which are usually provided by the lecturer in form of a printed reader. While this might seem unprogressive, many participants do not want to change this situation as they prefer reading printed instead of digital copies. Some even expect a higher learning effect by working on paper. However, if documents are provided digitally by the lecturer, they are usually processed digitally as well. One participant even takes the trouble to digitize all handwritten notes and handouts himself. Annotating and taking notes with digital tools is still perceived as complicated or not suitable for all situations, though.

When it comes to literature research, some departments (e.g. theology) still make use of card indices instead of computer workstations. From the student's point of view, especially the online provision of literature (i.e. essays and books, in particular) is still in its infancy. The participants strongly agree that all literature should be available online to avoid that students have to compete for scarce book resources or cannot access required literature in time for seminar papers. One participant who had previously studied in the Netherlands would even pay significant tuition fees for online access.

The administration of courses and examinations is another aspects of studying that is not yet digitized entirely. While registration processes usually take place online and are largely digitized, participants from the humanities report that in their discipline registration lists on paper are still used sporadically. The administration of examination results, on the other hand, is still mainly paperbased. Digital badges are not yet used. As regards attendance and performance records, paperwork is still dominant as well.

Overall, the students have a rather conservative understanding of digitalization which, essentially, includes the online provision of material as well as online registration possibilities. New forms of learning such as MOOCS, interactive classroom systems or even virtual reality are irrelevant, and mobility is not a big issue either. Students still predominantly study at home using a PC or a book. According to the them, this will hardly change in the coming years. Lectures where attendance is expected are also considered appropriate and future-oriented. Infrastructural aspects (e.g. audio-visual equipment in the auditorium, WLAN) were of very little importance in the interviews.

4.2 User Experiences with University IT Services

Discussing relevant university IT systems, participants primarily mention the Learnweb, the exam registration system QISPOS, the cloud storage service sciebo and the library online public access catalog OPAC. In addition, most participants use standard software which is available via terminal servers, the Office 365 software package which is available at a special price to university members, and, to a somewhat lesser extent, the e-mail service perMail. With the exception of the printing service Print&Pay, the students doesn't bring into focus other university IT services or infrastructures (e.g. websites, communication infrastructure, media technology).

While the Learnweb receives an entirely positive evaluation, the exam administration system QISPOS has the greatest potential for improvement from the students' point of view. Almost all participants have heard of or made negative experiences because the system apparently is complicated and generates misunderstandings. They have, for example, not received important examination results and thus had some serious disadvantages in their course of studies. Particularly foreign students seem to have difficulties with the low degree of standardization regarding exam administration procedures which differ greatly depending on the department, course combination, the responsible examination office and its respective system. Other universities have a different approach where students are registered for exams automatically with an opt-out option. Learnweb and QISPOS are university systems that students do not use in private contexts and, thus, there are little opportunities to draw comparisons. This, however, is different for university services with direct competitors from the commercial sector (e.g. sciebo vs. Dropbox or perMail vs. Google)

Numerous commercial services are used both, privately and for study purposes, mainly to perform communication tasks such as the exchange of information in group works or with lecturers. The real-time communication services of WhatsApp and Facebook are popular tools, for example, while the university's e-mail service perMail is avoided. The service is perceived as old-fashioned and complicated, but the main reason is the medium e-mail itself, which is deemed to be too formal, too slow, too complicated and too little group-based. WhatsApp, Facebook, Skype and Dropbox, on the other hand, offer easy-to-use functions for file sharing, video telephony, chat and status information. If e-mail services are used, it is those of commercial providers like Google or Microsoft which offer an integrated user experience. According to the participants, these services particularly benefit from their high integration with other services and their optimization due to fierce competition. In consequence, they are perceived as better developed and more intuitive. The fact that most students have already used popular commercial services before and will continue to use them after their studies is relevant as well: First, they do not have to learn and configure a new system, and, second, they can expect an already large user base which simplifies collaboration and data sharing considerably. In general, the participants are skeptical about university systems and see no need to replace commercial systems with university solutions. Participants who have studied abroad prefer the commercial solutions implemented there, with Google or Microsoft providing the basic services such as cloud, e-mail and Office software.

Overall, the user experience of university IT systems is rather poor. Students are particularly critical of those university services which they can compare to commercial alternatives from providers like Google, Dropbox or Microsoft. The latter are generally considered superior, as they must prove themselves in a competitive environment. Compared to commercial services, university services do significantly worse in terms of ease of use and look & feel. The participants consider the lack of integration, a feature that they value with services of commercial providers, as a major disadvantage of university systems. Most are not interfaced with each other or with privately used commercial services, so that students need a separate ID for each system. Moreover, media disruptions hinder their use. Thus, a convenient and seamless integration of all services (storage, collaborative work, e-mail, chat, Office applications) plays an important role in the preference for commercial providers. As a matter of principle, university systems have an image problem and some are not even given a try if commercial alternatives exist. The basic advantage of the university services – a higher data protection – is noticed by the students, but it has virtually no effect on their usage behavior.

4.3 Service Requirements of Students

As already mentioned, the students' pictures of a digitized university are less visionary, but rather pragmatic. Although most of the participants had an above-average technical background knowledge according to their self-assessment, there are hardly any suggestions that go beyond the improvement of existing services. However, the big issue outshining everything else is an integration and standardization of these services.

The service improvements and new services identified by the students can be divided into six categories: study organization & management, literature provision, software provision, learning and communication, minor improvements of existing services, and others. Overall, 19 services were proposed. Most fell into the category of study organization, followed by minor improvements of existing services such as a more stable WLAN or more favorable prices for printing. The three most important services were a centralized platform where all services are integrated (23 of 110 points, quoted by 7 of 11 participants), the online provision of literature (15 points / 7 quotations) and a standardized exam administration system (12 points / 5 quotations). All other services received less than 10 points and a maximum of two quotations. Seven out of 19 services received points from only one person, usually the proposer.

The centralized service platform stands out as a clear favorite – especially, since a dedicated university app with quite similar functionalities received another 8 points. In concrete terms, the students expect a portal in form of a website or an app, which requires only one login and merges the most important status messages, information and a transcript of records. The displayed information should be highly personalized and match their specific subject of study and their study objective (examination regulations, schedule, information about lecture rooms). Ideally, this application would be complemented by intelligent features, which – similar to GoogleNow – take over a counseling function. These features should, for example, display suitable course modules based on examination regulations and previously completed courses, calculate the overall average score or show the next appointment including relevant location plans.

5. DISCUSSION & PRACTICAL IMPLICATIONS

Although this pilot study can only give limited insights due to the small, non-representative sample and the specific situation at the University of Münster, it provides a lot of valuable information, especially for those responsible for university IT. A larger sample and quantitative methods would allow to test the validity of the results, support them in a representative way and transfer them to other universities. From a practitioner's point of view, the good news is that students – in contrast to the stereotype of the digital native and in line with the findings of previous studies (e.g. Bennett & Maton, 2010; Jones, Ramanau, Cross, & Healing, 2010; Kolikant, 2010; Lei, 2009; Margaryan, Littlejohn, & Vojt, 2011) – have a much more grounded and pragmatic view on the development in the next few years than company representatives suggest. In fact, the students understand digitalization primarily as the digital provision of lecture notes and online interaction possibilities with the university (i.e. registration for exams, communication with lecturers and fellow students). They do not demand a digital revolution in teaching or a fundamental reform of the academic studies (e.g. in form of mandatory online lectures). New learning formats such as lecture recordings or interactive elements are generally welcomed as additional possibilities, but they are not claimed for insistently. Nonetheless, students would appreciate a significantly stronger degree of digitalization, essentially in form of minor improvements of the core university IT services.

Three service categories clearly dominate the students' wishes for IT support: study organization, online literature and software provision. Great potential inheres in the creation of a centralized access to all relevant information and existing services (e.g. schedule, exam administration, certificates, study progress, contact information). But unlike most university apps which merely summarize general information with a cafeteria meal plan and a map, the students wish for a personalized solution that simplifies their study organization. From the students' point of view, IT should enable them to focus on the content of their studies, provide support for organizational problems, and grant easy access to resources, such as literature and software, while at the same time require little effort.

Against this background, a major problem of university IT could arise from the fact that users are affected by commercial services of large providers such as Google, Microsoft, Facebook and Dropbox. They expect the same integration of services they are accustomed to as well as an intuitive and simple way of use. But university systems are usually developed over many years due to historic reasons and operated decentrally. Thus, numerous unconnected systems co-exist (e.g. university library, data center platforms, university administration platforms, exam registration systems of various departments, various e-learning systems), making it necessary for students to use several IDs and understand different system logics. Furthermore, universities rarely invest in the design of their services, but focus on security aspects which are usually associated with a lower usage comfort. Students, in contrast, consider university systems as old-fashioned, complicated and less intuitive, and value security aspects rhetorically at most. In particular, the lack of integration of different services (and the accompanying need for different IDs for each system) is a major disadvantage. As the interviews indicate, most of the university services are no longer in the comfortable situation that they have to be used due to lack of competition, no matter how bad the user experience is. Commercial services from the private sphere are adopted in the university sphere as well, provided they seem suitable. In consequence, students argue for cooperations between universities and commercial providers such as

Google or Microsoft instead of university in-house developments, although there generally are diffuse concerns about data protection. Further research should examine in more detail the question which services the university itself should offer and which it should outsource to private providers (either completely or in form of a cooperation). Even though it is difficult to reconcile the desired user friendliness with the security requirements for university IT systems (which are particularly high in Germany), the results show that universities have to find a tradeoff. Above all, they are well advised to develop and implement digitalization strategies in order to actively shape this change.

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Essential IT capabilities for a successful digital transformation in Higher Education

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Keywords
Digital transformation, Higher Education IT, IT capabilities.

1. ABSTRACT

This paper discusses digital transformation within higher education and proposes a layered capability model for structuring the required IT capabilities. Changes related to digital transformation are taking place in most institutions and, while there are differences in the selected approaches, similarities can also be observed across the sector. To define the landscape, we use two frameworks to describe those changes. On one hand, we characterise various aspects of the digital transformation in higher education at the institutional level and, on the other hand, we analyse the new expectations for the role of IT within institution due to this change.

Our observations lead to the identification of a layered model of essential IT capabilities that are needed to cope with the ongoing change. We propose to use three layers. Firstly, *basic capabilities* are needed to provide a solid foundation for digital transformation within the organisation. These capabilities have already been part of best practices in traditional IT provision, but they are paramount to any attempt to engage in a digital transformation. Secondly, *standard capabilities* will be needed to maintain competitiveness in the ongoing change and will be essential for all institutions that are aiming at keeping abreast with their peers in the increasingly digital higher education business. Thirdly, *advanced capabilities* will be developed by those institutions that are aiming at using digital business as a competitive advantage. A single institution might not be able to excel in all these capabilities and, consequently, it is assumed that only a subset of them will be implemented in each organisation.

Due to the diversity of the higher education sector and the ongoing innovation in the digital business, this paper is not intended to provide a comprehensive list of the required IT capabilities. Instead, it describes an approach that can be used to evaluate and transform the IT function of any institution to provide sufficient support for the institution's digital future.

2. DIGITAL TRANSFORMATION IN HIGHER EDUCATION

Digital transformation in different ways, the growing value of digital business, and the increased impact of information technology have all been significant change factors for all businesses for a couple of years. Each sector is experiencing a slightly different version of this phenomenon at the strategic level (Matt, Hess, Benlian, 2015). Within the higher education sector, we can observe several changes and new opportunities arising as illustrated by Figure 1 (Kähkipuro, 2015).

External changes are visible to the outside world and influence the way the institution operates towards its stakeholders. For example, the business model of the institution might change with the introduction of on-line and blended learning models. We have seen interesting partnerships between institutions and organisations that provide online courses for them on a revenue sharing basis (Newton, 2016). In the same way, institutions can use different digital tools, such as portals, mobile applications and social media, to change the student experience all the way through from the start of the recruitment process to their entry to the alumni stage. Similar externally visible changes may be implemented for other stakeholders as well.

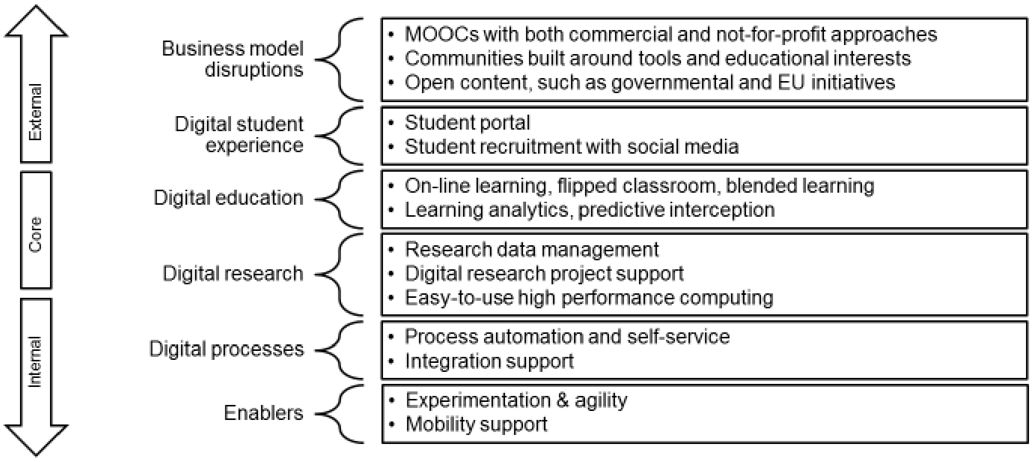

Figure 1. Aspects of digital transformation in Higher Education.

There will also be changes affecting directly both education and research, i.e. the *core business*. On the educational side, online learning practices and traditional methodologies can be combined in different ways to support blended and online learning. The use of digital technologies will also enable supporting activities, such as digital assessment, learning analytics and early interception, to be conducted in news ways, see e.g. (Davies, Mullan, Feldman, 2017). On the research side, the emergence of open access, open data and other digital opportunities will change the scenery. Also, high performance computing and other numerical techniques will be available for a broader group of researchers in domains where such techniques have not been used in the past.

There will also be *internal changes* in the way institutions operate. Institutions will be able to improve their working practices by using modern tools and techniques and by integrating existing tools with new ones. Productivity of individuals will increase from the increased support for mobility, cloud services and other new technologies.

3. THE ROLE OF THE IT FUNCTION

The above changes describe the aspirations at the institutional level. However, to implement the desired change, there is a need to support the transformation at all levels of the organization. One of the most critical elements is the role of the IT function.

To analyse the change, we use a simple framework for classifying the role of the IT function within an organisation. The framework has been adopted from a model initially suggested by Gartner Inc. (Gartner, 2014). Figure 2 illustrates the framework and how typical IT organisations in higher education position themselves. The 'Orientation' dimension indicates how much the IT function is involved in running the business-as-usual versus how transformational it is. Transformational aspects may, for example, be related to increasing personal productivity through external services or new technologies even if this improvement is not directly based to the use of corporate tools. The 'Focus' dimension is about the visibility of the IT services and how much internal and external exposure it gets. Typically, an IT organisation gets external visibility through partnering with other units.

In most cases, an IT organisation operates in all four sectors of the framework, but the focus tends to be in the lower left corner, in the 'engine room'. To a lesser extent, IT can be involved in joint service initiatives with other service unites (upper left corner) and in supporting exploratory use of digital technologies (lower right corner). Some institutions have taken a strong step towards online provision and this is when IT is also visible in the core activities (upper right corner).

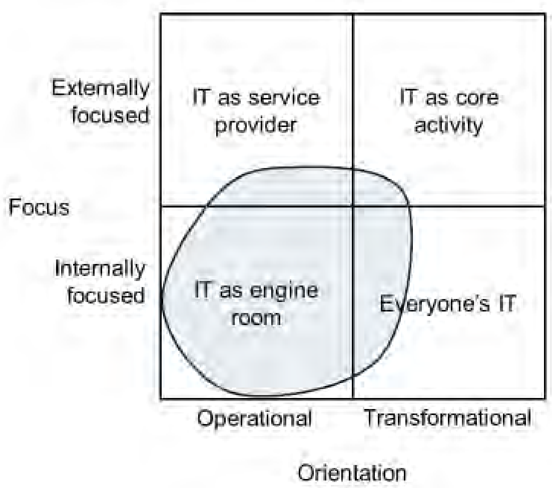

Figure 2. Typical role of the IT function in higher education.

4. FIVE AREAS OF CHANGE FOR THE IT FUNCTION

The requirements for digital transformation discussed in section 2 manifest themselves in a number of forces visible to the IT organisation. At least the following forces can be observed:

1. IT is expected to be more involved in providing services beyond traditional IT. Typical examples include automated HR services for the staff and administrative services for the students. Also, IT's own service provision is expected to turn from technology support into a broader range of services, such as access to electronic information resources.
2. IT is expected to support the increase of personal productivity of staff and students by providing support for mobility, bring-your-own-devices, external cloud services and new technologies.
3. IT needs to be increasingly involved in the core activities of the institution. In education, this involves work with areas like online learning tools, digital assessment and learning analytics. In research, new requirements for open access, open data and numerical methodologies among other things tend to consume an increasing part of IT resources.
4. Due to the increased focus on the above items, less resources will be available for traditional IT work and, consequently, there is a need to shift part of the traditional infrastructure work outside the organisation. New partnering and procurement practices will be needed.
5. The shift of focus in the above elements will require new management practices: the IT provision needs to move from technology to services and, ideally, to a true partnership with the rest of the organisation.

Figure 3 illustrates these five forces using the framework introduced in the previous section. We will illustrate these five areas with several examples in the rest of this section.

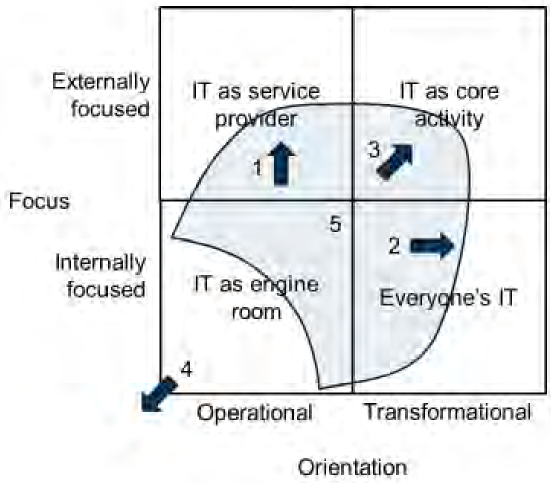

Figure 3. Five areas of change for the IT function.

1. From infrastructure to services. In the future, the IT function is expected to provide a robust and agile platform for all services independent on whether they are intended for internal or external customers. This typically includes a combination of new capabilities, such as

- Tools and processes for Identity and Access Management to enable automation and self-service,
- Tools and processes for consistent service management within and outside IT,
- Basic integration capabilities and an Enterprise Service Bus,
- Advanced integration and service orchestration capabilities,
- Tools for automation and self-service,
- Ability co-operate with other service functions to create joint service processes.

2. Improved personal productivity. The IT function is expected to provide agile support for all kinds of personal productivity improvements independent on whether the technology is provided by the organisation itself or by an external supplier. Support will be needed for new services, new devices and new applications. Typical examples include

- Technical support for using bring-your-own-devices (e.g. seamless network access),
- Integration with selected cloud services and corporate systems,
- Legal support for using external services. This can range from a list of recommended services to corporate level agreements with selected service providers,
- Cloud-like user experience for corporate systems so that they can be accessed with any kind of client devices,
- Mobility support on-campus and off-campus.

3. Greater role in core business. In higher education, with the availability of highly sophisticated digital tools for education and research, there is clearly a demand for the IT function to take a broader role. Typical examples include tools and processes for the following (Kahkipuro, 2015):

- Online learning, flipped classrooms, blended learning, digital assessment,
- Learning analytics, attendance monitoring, predictive interception,
- Research data management,
- Digital research project support,
- Easy-to-use high performance computing.

4. Step away from traditional IT. To keep the amount of IT resources under control, and to shift the focus into new areas, there is a need to abandon part of the traditional IT work, especially work related to the infrastructure. Typical examples in this area include the following:

- Change the primary strategy from 'make' to 'buy'. This may include a *cloud first* strategy and gradual outsourcing of selected parts of the IT infrastructure (van Gaver, 2016).
- Change the back-end approach from 'operations' to 'service delivery'. With this change, the IT organisation will be able to use external partners in many cases where they have traditionally been implementing the full service by themselves,
- Extend the skill set for the IT staff in the areas of service procurement and outsourcing.

5. New management practices. Less focus for traditional IT will require an explicit change in management style and IT's goals. This will be visible at all levels. Examples include:

- Change in the organisation, such as merging IT with other service functions or introducing a matrix model where IT matters are better integrated with the rest of the business,
- The introduction of a Project Management Office to support the organisation, including the IT, to improve the management of business change,
- Change the customer facing approach from an 'IT service desk' to a 'one stop shop' that will be able to deal with technical and non-technical problems alike,
- Extend the skills of the IT staff for engaging with the rest of the organisation (e.g. business analyst skills, procurement skills and change management skills),
- Enable projects with multiple modes: both agile and traditional projects have their place,
- Update the IT governance. Change the IT board to be more business focused, introduce business relationship management practices into the organisation, and publish an IT strategy that addresses needs beyond technology.
- Extend data security beyond the technical domain to encompass all relevant aspects of security, including data privacy and governance practices.

Essentially, the last item turns 'customers' into 'partners' and enables the IT organisation to manage its own destiny as part of the entire institution.

5. LAYERED CAPABILITY MODEL

The above list of identified requirements might look overwhelmingly long and difficult to implement. However, for an institution to be able succeed in the increasingly digital world, these requirements can be arranged into a prioritised set of capabilities to provide a more accessible way to deal with the change. To this end, we have defined a layered capability model with the following three layers:

- *Basic capabilities*: these capabilities have been part of IT best practices for years but digital transformation had made them essential for a sustainable future. Failing to implement them properly will seriously affect the institution's future in the digital world.
- *Standard capabilities*: these capabilities are required to be in the mainstream but do not provide any competitive advantage. These capabilities will define the norm for future higher education institutions.
- *Advanced capabilities*: these capabilities can be a source of competitive advantage, and not all of them need to be implemented in a single organisation. Typically, such capabilities are not only related to information technology but also to one or more additional aspects of the institution.

Within each layer, we have loosely identified capabilities that are related to technologies and services and those that are focused on the organisation and processes. The borderline between these two categories is not exact and most capabilities have elements on both sides. See (Daub, Wiesinger, 2015) for a more generic view on digital capabilities and how organisations can acquire them.

Figure 4 illustrates the layered capability model populated with capabilities that are directly related to the requirements identified in the previous sections. Due to the diversity of the higher education sector, the figure is not intended to be a comprehensive representation of the ongoing digital transformation. Instead, it provides a structure and examples to help institutions to assess their own capabilities in order the define their strategy work.

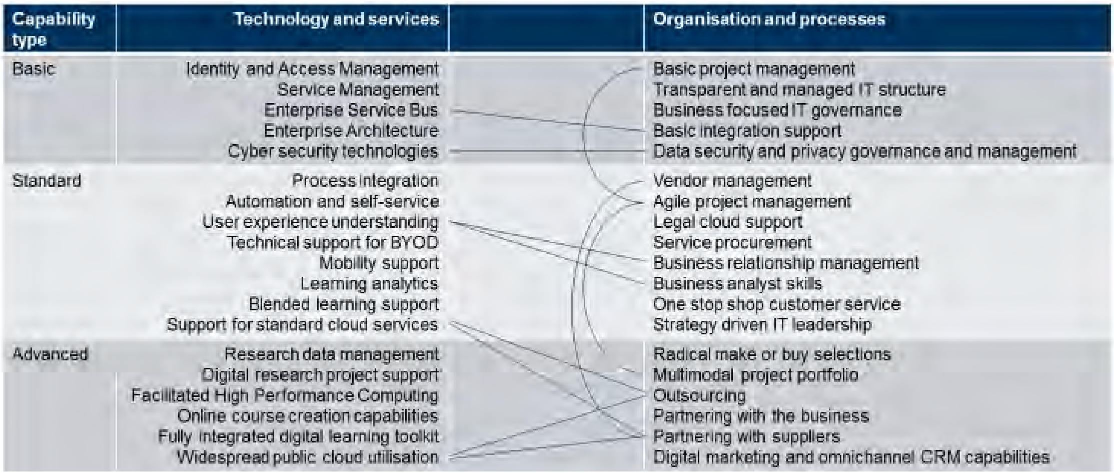

Figure 4. Layered IT capability model for digital transformation in higher education.

The *basic layer* is an area where the IT organisation needs to catch up with industry best practices. To start working on these capabilities does not require any significant changes in IT's role or goals, and appropriate projects can be typically initiated using existing governance mechanisms. There is a solid business case for each one of them even without reference to the digital transformation.

The *standard layer* provides the most challenging part of the oncoming work, as it will require the involvement of the entire organisation, significant technical investments and changes in the governance model. One of the most challenging parts will be the establishment of an IT leadership model that links IT (and the underlying digital capabilities) to the institutional strategy. Such a leadership model will speed up the creation of the other standard capabilities but, even then, the work will require several years if the starting point is a typical higher education institution. For an institution to be at par with the rest of the industry, most standard capabilities need to be present. This layer will define the new norm for higher education IT.

Finally, the *advanced layer* needs to be addressed differently. Rather than spreading resources in multiple directions, institutions will need to align their advanced digital capabilities with their institutional strategy. This way, resources will be used in the most efficient way and digital transformation can provide a source of differentiation. Projects at this layer need to be treated not as 'IT projects' but as strategic business projects, and they should ideally be managed as a part of the institution's strategic project portfolio.

There are natural interdependencies between the capabilities and some of them have been indicated by the connecting lines in Figure 4. For example, a technical capability may be connected to one or more related capabilities on the organisational side. Such dependencies point out the need to achieve results on one side before being able to progress on the other side. Some of the dependencies extend over the layers and indicate prerequisites for an organisation to be able to proceed to the next layer.

The capability model does not make any assumptions on the structure of the IT function. The same capabilities can be implemented with both distributed and centralised organisations. Also, the same capabilities can exist in the presence of a separate 'digital organisation' or in a structure where the same IT organisation is responsible for both the new and the old worlds.

There is an embedded positive message underlying the above analysis. While it is quite clear that the traditional IT service function in higher education will not be enough for the institutions to remain competitive, it is clearly possible to develop the existing IT function to deal with the new requirements.

6. SUMMARY

In the beginning of this paper, we have identified several changes brought about by the digital transformation at higher education institutions. Some of the changes will be visible externally, some of them will address the core activities, and some of them will have mostly internal implications. In addition, we also identified several forces affecting the role of the IT function within the institutions. Again, significant changes are expected to take place in the IT service provision.

To address the above requirements, institutions will need to increase their IT capabilities in different ways. To this end, we have introduced a *layered capability model* with three layers. The *basic layer* collects those capabilities that are part of traditional IT and have become essential in the digital era. The *standard layer* consists of capabilities that are required for institutions to stay in the mainstream in the future. The *advanced layer* provides capabilities for differentiation.

The capability model directs institution to address different layers in different ways. The basic layer can be addressed using traditional IT methodologies and governance models. The standard layer will require more work from the organisation, but it will become the new norm for IT in higher education and, hence, it is important to start working on these elements as soon as possible even in the presence of added organisational friction. Finally, the advanced layer provides means for strategic differentiation and needs to be addressed as a part of the institution's strategic portfolio.

The presented set of institutional aspirations might be typical for some organisations but institutions should take their own strategies as the starting point and follow the same steps to create their own list of required IT capabilities. Due to the different strategic directions taken by different organisations, there will be significant variations at the advanced layer and, consequently, the ensuing implementation projects will look very different. This is clearly an area of further research.

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8. AUTHOR'S BIOGRAPHY

Pekka Kähkipuro is Chief Information Officer at Brunel University London since 2016. He is heading the Information Services Directorate responsible for both ICT and Library services. Prior to joining Brunel, Pekka was Director of IT at Aalto University in Finland in 2010-2016 and, before that, he held various senior roles in the private sector including Nokia. He was EUNIS board member in 2011-2015 and the President in 2015. Pekka obtained his Ph.D. in computer science from the University of Helsinki in 2000.

BENCHEIT – BENCHMARKING HIGHER EDUCATION IT

AN UPDATE ON THE WORK OF THE EUNIS BENCHEIT TASK FORCE

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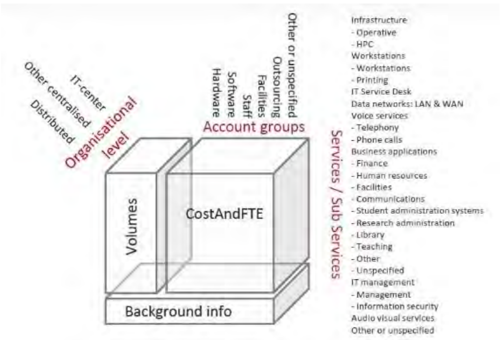
Keywords
benchmarking, BencHEIT, CIO, IT management, costs

1. Summary

BencHEIT is a free of charge yearly survey with the aim of establishing a comprehensive knowledge of how cost efficiently IT works in European universities, and universities of applied sciences. The BencHEIT Task Force gathers the data and generates an analysis for the CIOs to use in comparing the organization´s IT costs and volumes to their peer´s numbers. It also provides them with tools to start more detailed discussions how to improve the performance of institute's IT services. Analysis gives some perspective to common development within the higher education IT.

Data is collected in three dimensions:



1. Organizational level: centralized IT, other centralized units, distributed units e.g. faculties and research centers. This way participating organization can see how (de)centralized their IT is in comparison to others.
2. Account level: financial data is divided in hardware, software, staff, facilities, outsourcing and other costs.
3. Services: all costs and also some of the volume data is collected within different IT services e.g. infrastructure, workstations, business applications.

The initiative was started as a country-wide Finnish project, but in the year 2012 it was opened to all European HEIs that were interested. The number of participants have increased every year since the project started in its current form in 2012. In the last round there were 57 participants from 11 countries.

For the past five years, the Task Force has hosted workshops together with EUNIS. Last December in Trondheim we had about 40 participants talking about different ongoing IT benchmarking projects in Europe. This year the meeting will be in Lisbon on the 13th of December. We will also have a session after the presentation at the EUNIS congress, where we go deeper into the results. We also hope that everyone who is interested in participating in the future, would come and talk to us and hear more about what we are doing, and how their organization could benefit from the exercise.

BencHEIT is one of the EUNIS official task forces. This presentation aims to be both a short summary of what the BencHEIT aims and benefits are, but also to give a glimpse of what new results have been obtained during the latest benchmarking round during January-April 2017.

In our presentation we will present the project and the process. As the analysis will be ready in late May 2017, the EUNIS Congress is the first time we reveal some of the results and key findings from the last round. We will also show historical development of a few indicators during last six years of benchmarking process.

There is a new voluntary part of the survey concerning the EU General Data Protection Regulation. In May 2016 EU regulation for privacy data was published and it should be applied in year 2018. BM2016 survey aims to obtain a view of the readiness of organizations to fulfill this regulation. Based on these questions we can find out what the overall status of preparing to GDPR is.

2. AUTHORS' BIOGRAPHIES

Ilkka Siissalo is the CIO of University of Helsinki, EUNIS President and chairman of the BencHEIT steering group. Ilkka holds an M.Sc degree in biochemical sciences as well as a bachelor level degree in marketing. Ilkka has acted as the IT leader in various research related institutions both within the private sector and academia for over 25 years.

Teemu Seesto has M.Sc. in economics from Turku School of Economics. He has been a teacher of information systems science for twenty years. Seesto was the CIO of Turku School of Economics during 2006-2010. He is currently the IT general secretary of FUCIO, the Network of Finnish universities' CIOs. Teemu is a member of the BencHEIT steering group

Yvonne Kivi is an IT specialist at the University of Helsinki and the project manager of BencHEIT. She holds a B.Sc degree from Arcada university of applied sciences. Yvonne is the key contact person to most of the institutions that participate in the BencHEIT work.

The Value and Quality of Maturity Models

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Keywords
Maturity Models, Benchmarking, Quality,

1. SUMMARY

This session opens up for a discussion about the value and quality of using maturity models. Different aspects will be highlighted and scenarios will be reviewed.

The maturity model frameworks provides a structure to help organize when developing business areas. We use the maturity model as an enabler when benchmarking with other organizations. But how are we supposed to communicate and ensure the quality of the maturity model used and the result. The objective must be to provide a structured approach that ensures quality.

Lesson learned and outcome will provide the context for a discussion with the audience.

2. ABSTRACT

Maturity models has been on the market for a long time and they have been questioned but also helpful for setting up goals developing business areas. Using maturity models has become more common in our sector over the last years and involving different areas and organizations rises some questions for me. I feel that the approach to how they are being used varies between users. For example I experienced a gap between the ones building the model and the teams answering/using the model. Sometimes, depending on the different levels of knowledge in the subject. Actually, how mature are we when it comes to using maturity models.

I had a discussion with a college from another university explaining how we worked with our disaster recovery planning process. He was reflecting and said that he thought that on a maturity level we were a 4 or a 5 and they were a 2 still having some work to do. I think that we both had the same picture when it comes to maturity levels and that we actually understood each other.

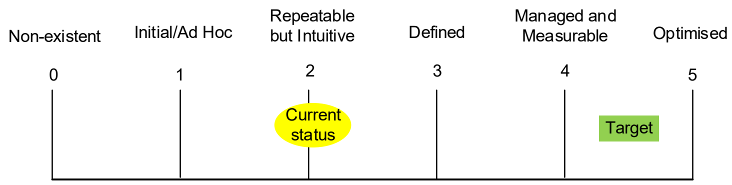

Figure 1 Level of maturity for a process or service

But often the case is that the teams are not that familiar with using maturity models. When we developed our Service Desk I used the maturity model COBIT 4 supported. And when we implemented a framework for our Enterprise Architecture I used NASCIO maturity model moving from strategy to target.

Introducing the models to the teams raised some questions. One team found it difficult to land the attributes to an output level. They wanted to plot it in all levels. I can understand that – but it's important to find a level to start from moving to the next step. A group of managers responsible for one business area marked their organizations on the same level without even questioning the attributes on the different levels. Okay, everyone is a 4, do we have anything to improve. I felt that we missed the quality in the result. It's normally expensive to keep a process between 4 or 5 and the organization has to decide which processes are the most important ones. Often level 3 to 4 is good enough. All universities in Sweden has answered a survey covering nine dimensions. The maturity model included 7 levels and, according to me, the description for each level opened up for misunderstandings and made it difficult to get a good quality in the result.

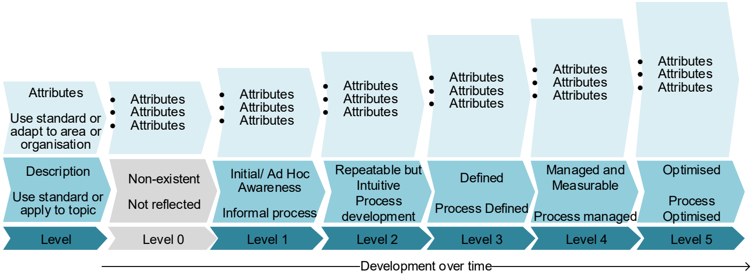

Figure 2 Maturity model framework

On the market there a standard models such as CMM and P3M3. Often we adapt them to a specific area, creating one model for organizational use and another model for a specific business area. Do we need different models for different purpose? Do we recommend the same model if we want to identify business areas needing improvement in our organization or if we want to create a benchmark between organizations?

The quality is important. I think the result depends on who familiar we are with maturity models and how well the attributes are described. The objective must be to provide a structured approach that ensures quality.

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4. AUTHORS' BIOGRAPHIES

K. Westerlund. I work as an IT-strategist at Umeå University since 1997. I am a part of the IT Office and we have a mandate from the University Management to take strategic responsibility for all common IT at the university. At the beginning of the 90s I worked as a development strategist at Umeå University and in the sector. Between the years 1994 to 1997 I worked as a project manager and was responsible for the development of an IT system supporting human recourses, named Primula, for higher education in Sweden. During the years 2006 to 2012 I was a member of the Ladok Board. I have studied, economics, law and informatics at Umeå University.

Observations from the current CIO surveys in Germany – linking CHEITA's global complexity index (GCI) to other factors and frameworks

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Keywords
IT Governance, German Higher Education Institutions, Global Complexity Index

1. Abstract

The CIO surveys in German Higher Education Institutions (HEI) allow a unique access to the development process of different IT-Governance implementations across a diverse developed university culture. This culture is often influenced by the traditions, the history and local politics in a specific way but also with a large variety. Not at all surprisingly, the individual HEI only slowly adopts different practices which primarily had been developed in countries with high tuition rates and thus a greater need for cost control and overall guidance. This paper therefore investigates if and how an overall benefit is visible for those institutions which build and implement a specific IT-Governance.

The application of the global complexity index being developed by the CHEITA community as a baseline for comparison does reveal additional valuable insights. Especially the lack of payoff in the application of service management frameworks and increased benefit of the continuous awareness around information security becomes visible. Institutions investing in security awareness show a better spending rate in comparison to their peers on the GCI scale. Institutions spending their budget on the optimisation of the service portfolio fail to demonstrate their advantages. In general, bigger institutions allow their CIOs better to follow their goals. They also grant their CIOs effective access to the board of directors. In consequence, those CIOs can demonstrate a higher value of IT for their institutions.

2. Background

IT Governance has been addressed in German HEI for about 15 years. Initially, recommendations were given by the German Research Council (DFG) and other organisations (DINI, HRK, ZKI) in a general way (Deutsche Forschungsgemeinschaft, 2001; von der Heyde et al., 2009; Meyer-Doerpinghaus, 2012; Degkwitz & Schirmbacher, 2015; Deutsche Forschungsgemeinschaft, 2016). Several surveys were conducted to look into the development of IT Governance as case studies (Schwabe, 2009; Börgmann & Bick, 2011; Grönert, Pöppelbuß, & Breiter, 2014), from the perspective of the ICT departments (Hotzel, Wimmer, von der Heyde, & Lang, 2016), and also from a statistical point of view (von der Heyde, 2014a, 2014b, von der Heyde & Breiter, 2015, 2016).

Main questions in these quantitative surveys were:

- Are there typical models of IT Governance implemented?
- How do organisational processes change to support IT-Governance?
- What are the respective advantages of those models?
- Are there other indicators explaining the success of the different models?
- How does the financial situation link to the governance model?

Recently a more detailed comparison of various institutions (so called IT-Benchmarking) also started in Germany, linking the community to the benchmarking initiative of EUNIS and CHEITA.

2.1. Sizes of HEI in Germany

Generally, the sizes of HEI in Germany are very diverse (see Figure 1). A high number of specialized universities with few students lower the median to only 2620 students. The average of 7008 students indicates that majority of the students is enrolled in only a few HEI. This is important regarding the perceived necessity to establish IT Governance and IT strategy in HEI of larger sizes.

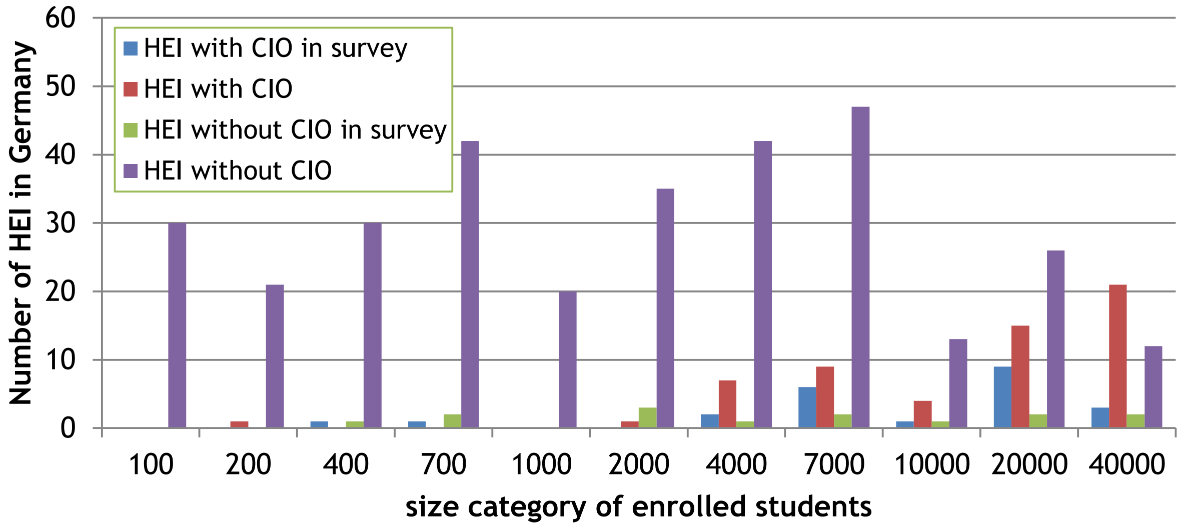


Figure 1: Number of HEI in Germany grouped by size with up to N students (Source: HRK statistics, May 2016). The participation in the CIO survey 2016 is split into separate columns. The number of institutions with CIOs was estimated on the basis of previous years' surveys.

The overview in Table 1 shows the number of institutions who participated in the 2016 survey. Again the total sum of students shows the concentration of large student population in the research oriented universities in contrast to schools of music and arts or the universities of applied sciences.

Table 1: Size of HEI in Germany in May 2016. In brackets the percentage who participated.

Type of HEI	Number	Sum of students	HE participants in survey 2016	HE institutions with CIO
Research oriented Universities	110	ca.1.740.000	23 (ca. 21%)	ca. 50
Schools of Music and Art	54	ca. 36.300	2 (ca. 4%)	ca. 5
Universities of Applied Sciences	228	ca. 968.000	17 (ca. 7%)	ca. 30
Sum	**392**	**ca. 2.750.000**	**42**	**ca. 85**

2.2. Participation in the CIO survey 2016

In the 2016 survey 42 HEI submitted data that is included in the further analysis. Table 2 shows the overall numbers which are represented by the 2015 and 2015 data sets. In proportion to all German HE institutions, the 2016 survey covered institutions with about 17,8% percent of the student population.

Table 2: Overall numbers *represented* by the 2015 and 2016 survey in comparison. In relation to the overall student population of Germany (2,75 Mio) the surveys cover a substantial part. Numbers in brackets indicate the number of datasets being included in the sums.

	Sum students	Stud. proportion	Sum budget	Sum staff	Sum IT budget
Survey 2015	401.939 (38)	14,6%	2.733 Mio (19)	57.671 (35)	24,4 Mio (27)
Survey 2016	490.303 (42)	17,8%	3.939 Mio (36)	67.079 (42)	46,4 Mio (18)

The t-test for the student numbers of all participating HEI in comparison to all HEI in Germany confirms a representative sample (p=0,023). For the sub-sample of those HEI where a GCI is known, the t-test results in p=0,025. The survey therefore covers a substantial part of the German HE landscape.

3. Method

The complexity index is defined as a linear combination of normalized number of students, number of employees, and research funding:

student_index = min(10,1+9*(student full time equivalents / 45.000))
staff_index = min(10,1+9*(staff full time equivalents / 18.000))
research_index = min(10,1+9*(external research funding / 750.000.000))
complexity index = student_index * 35% + staff_index * 35% + research_index * 30%

The complexity index is therefore by definition correlated to those values. It was originally developed including the various scaling factors by the Australian federation of HE (CAUDIT).

The Global Complexity Index (GCI) was adapted to reflect the currency and purchasing power of international HEI for the research_index as defined by CHEITA (Bergström et al., 2015).

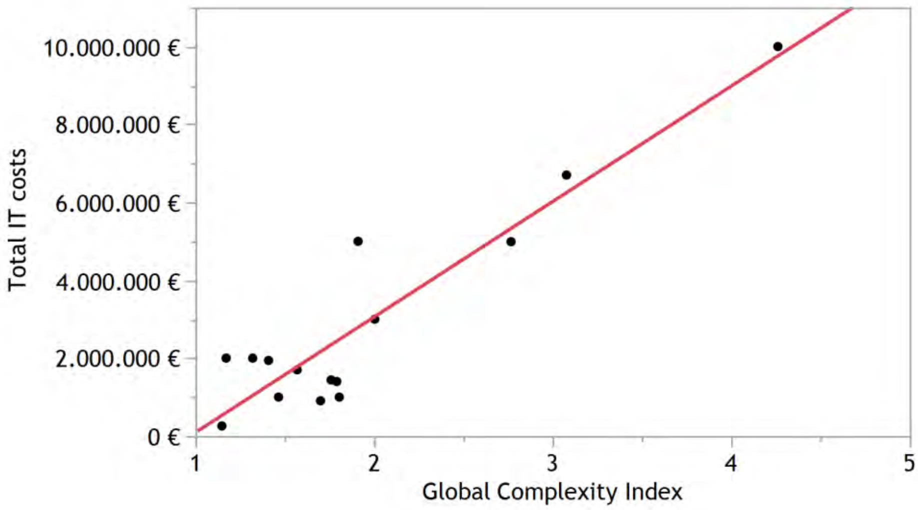
This paper links data and further results of the German CIO survey 2016 (von der Heyde & Breiter, 2016) to the GCI. The survey data of 2016 was collected with a web based questionnaire send to the CIOs, IT directors or, if those could not be electronically located, to the board of directors of all German HE institutions. About 110 participants showed initial interest; however, only 42 completed the survey questions to a degree, that allowed further data analytics.

4. Results

The basic statistical analysis applying U-Tests shows not only the expected correlations of the GCI with size of the institutions, but also with

a) organisational aspects – e.g. the Governance model between central IT and the CIO,
b) the communication of the strategic value of IT,
c) the planning processes for the IT service portfolio,
d) the application of information security frameworks, and
e) the confidence of the CIOs to follow their goals.

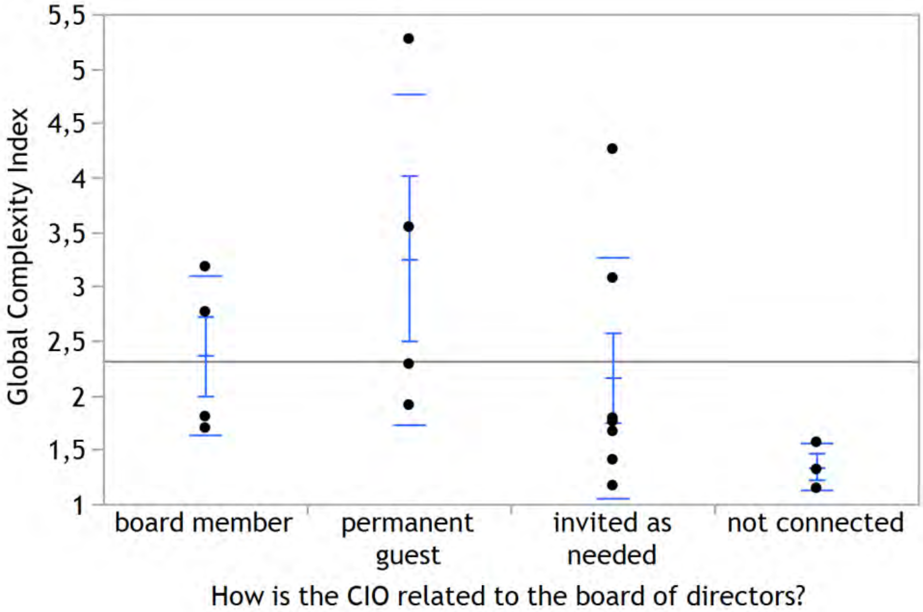
Sometimes these aspects could statistically be correlated with the GCI or with the difference between the actual IT budget and the budget predicted by the GCI. In some cases, the statistical analysis did not indicate a clear correlation to the underlying factors of the GCI.



In general, the total IT spending of the institutions could be fitted linear to the GCI. The r^2 of 0,85 suggests that the major determining factors for IT spending are covered by the GCI. This confirms earlier reports (Bergström et al., 2016).

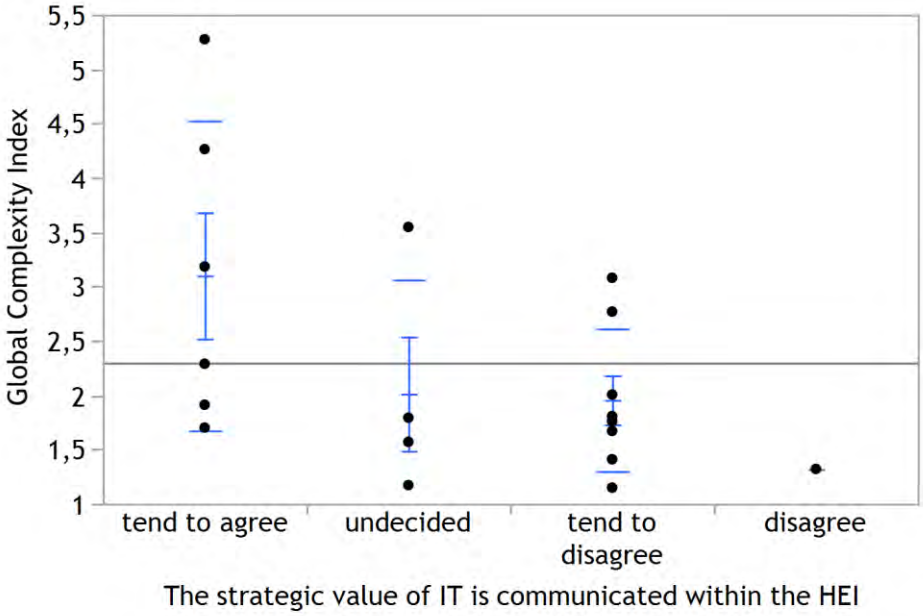
4.1. Access to the board of directors

Apparently there are relations between the GCI and the implementation of IT Governance. The ways CIOs have access to their boards of directors differ substantially with the GCI. Often institutions with a small GCI have not established any link between CIO and the board (average GCI 1,3, n=3). The average GCI for those inviting the CIO to the board when necessary is 2,2 (n=7). In some institutions (n=4) the CIO is member of the board (GCI average of 2,4). The highest average GCI of 3,3 have the institutions (n=4) where the CIO is permanent guest of the board granting constant access to the information, but leaving the decision domains within the board.



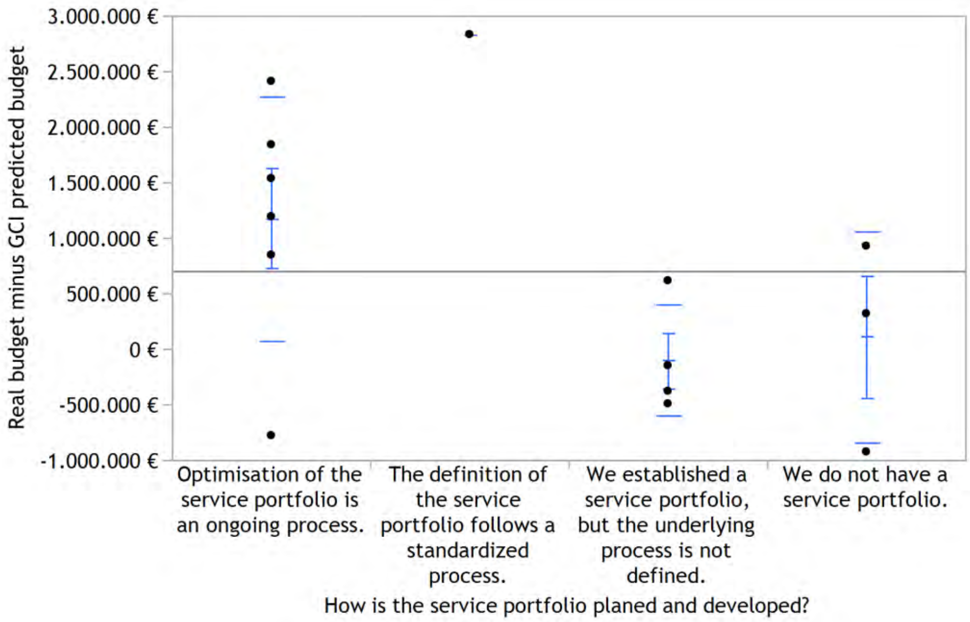
4.2. Strategic value

The communication of strategic value of IT also seems to be related to the GCI. Those who claim to have established this communication have a GCI of 3,1 on average, which is significantly higher than the rest of the HEI (average of 1,8 GCI). Surprisingly, this variable does not significantly correlate with the individual factors of the GCI (number of students, staff and research funding).



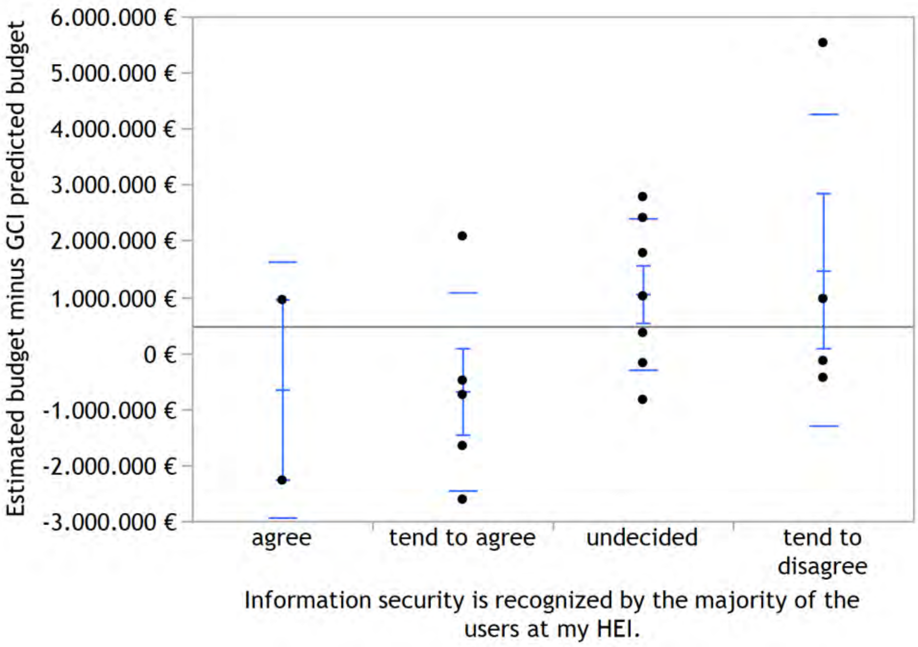
4.3. Optimisation of the Service Portfolio

The HE institutions who optimise their service portfolio in a defined process also tend to have a higher IT budget than the GCI would predict (about 1,1 Mio. €). In contrast, institutions who have a defined service portfolio but not a defined process to optimise it have roughly the budget the GCI would predict (on average 0,1 Mio € more). This does not confirm the common expectation that an optimised service portfolio reduces costs over all. In contrast, the service optimization required often more money than the GCI would predict.

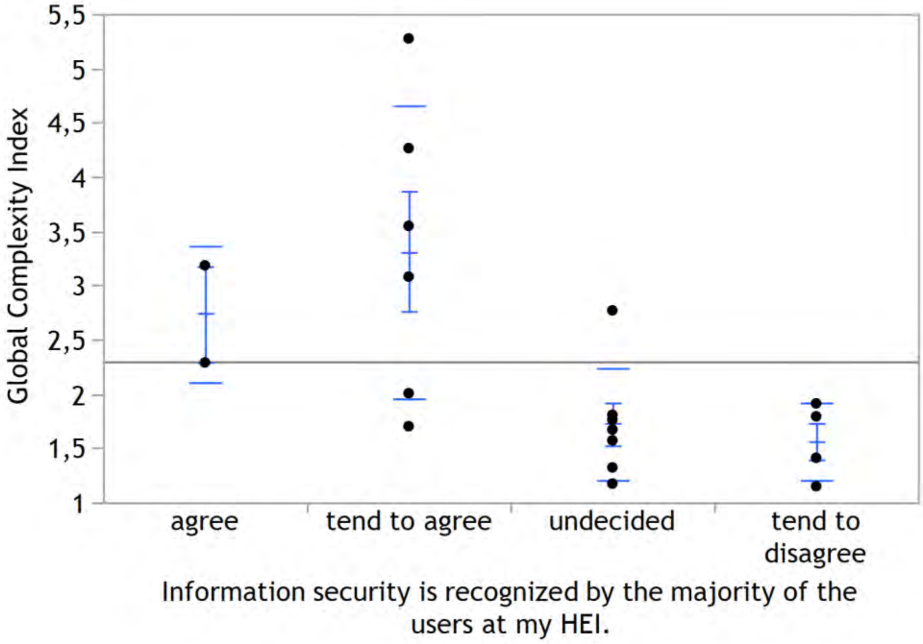


4.4. Information security is recognized

HEI where information security is recognized by the members as an important issue tend to need less money in comparison to their GCI predicted spending than those where information security has an unknown or not well established recognition. In other words, a good awareness in information security can potentially save money.

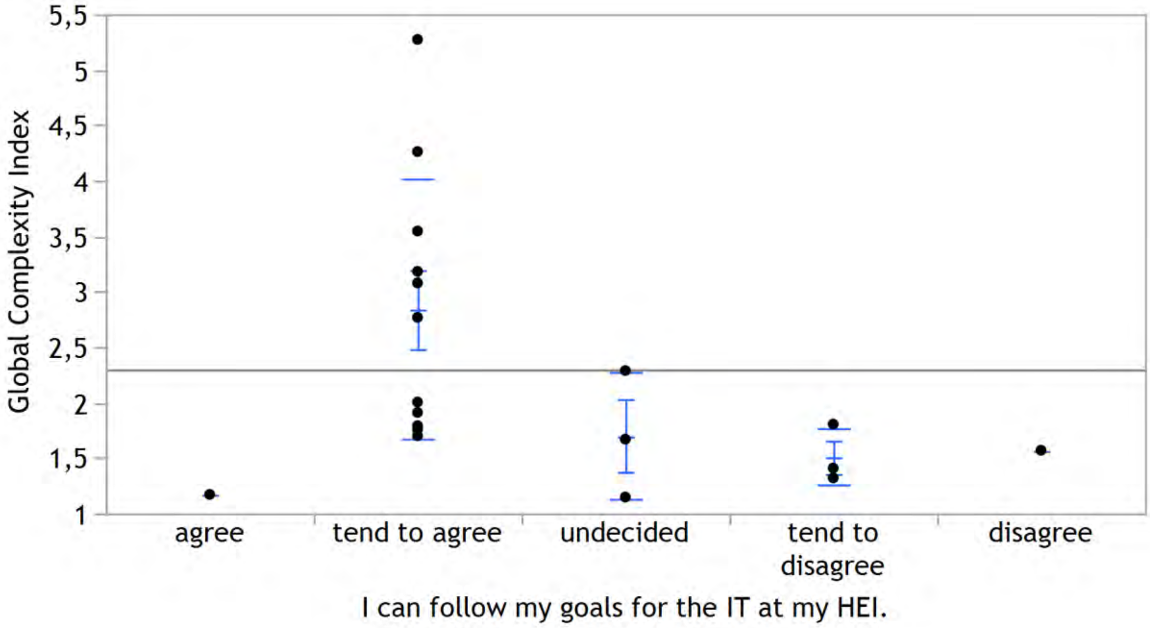


However, this is also intermixed with other factors like the size of the organisation being correlated with the GCI. So far information security is mostly recognized in its importance by universities with a GCI above 1,8 (average round 3,0). This leaves the universities with an average of 1,6 GCI with incomplete awareness for information security issues.



4.5. CIOs are able to follow their goals

CIOs who report to be able to follow their goals coherently are often located at HE institutions with an average GCI of about 2,8. Others who are either unsure or reject this statement are mostly at institutions with a GCI below 2,4 and with average around 1,6. This confirms the higher flexibility of bigger institutions to support their CIOs in the efforts to organise IT.



5. Summary and outlook

The CIO surveys in German HE allow a unique access to the development process of different IT-Governance implementations. Our research in this paper focuses on the link between different governance aspects, the processes around the service portfolio, the awareness of information security, and correlations to the global complexity index (GCI).

The expected payoff to optimise the HE service portfolio could not be observed, but in contrast to expectations, we observed higher costs for optimised service portfolios.

The continuous awareness of information security pays off. Institutions with a higher awareness spend on average less money based on the predictions we concluded from the GCI on IT spending.

Large institutions allow their CIOs better to realize their goals and communicate the strategic value of IT. We hypothesis the underlying cause is the effective access of the CIO to the board of directors at the these HEI.

Further investigations are needed to understand the underlying causes for our observations. Additional valuable input would be expected by the international comparison of our findings within the EUNIS community.

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7. Authors' Biographies

Dr. Markus von der Heyde received his PhD in Computer Sciences from the University of Bielefeld for his work at the Max Planck Institute for Biological Cybernetics Tübingen in 2000. His approach is to adopt biological principles into distributed computer applications in order to enhance stability and robustness.

Since 2004 he has worked within ZKI on topics as information security, service-management, strategy and governance. Until 2011 he was ICT director of Bauhaus-University in Weimar. Until today he also focuses on internationalization and supports ZKI, GI, EUNIS and EDUCAUSE and serves as program committee member as well as a proposal reviewer for conferences and the scientific community. In cooperation with various partners he conducts the German CIO studies since 2014. Today, he is management consultant specialized on IT topics in higher education. More details on https://www.researchgate.net/profile/Markus_Von_Der_Heyde3.

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Future challenges for quality-assured IT support through cooperative structures

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Service Management, support, cooperations, transformation, future prospects, professionalization

1. ABSTRACT

In the future, various new challenges will arise in quality-assured IT support at universities. University computing center are increasingly being encouraged to provide IT services not only for their own universities but for other universities and research institutes as well. Additionally, cooperation between various university IT service providers is essential. The joint service of different service providers of a university for additional external facilities leads to the need to adapt existing support structures in order to continue to guarantee the best possible quality of service. In the following these new challenges will be examined using the example of the IT Center at RWTH Aachen University within the context of transformation of support structures.

2. MOTIVATION

The IT Center of RWTH Aachen University is one of the central IT service providers at the university (apart from the central university administration (ZHV) and the university library (UB)). The service catalogue of the IT Center includes the provision of approximately 50 basic and individual services to students, staff, and the facilities of the university, as well as external cooperation partners. These services include identity management, e-mail, telephone, data network, backup, managed services for institutes and the CAMPUS information system.

In order to better meet customer needs and requirements IT Service Management (ITSM) was introduced in 2008 according to the IT Infrastructure Library (ITIL). This is a de facto standard that define IT Service Management through good practice guidelines and incorporates it organizationally.

Objectives of ITSM at the IT Center of RWTH Aachen University:

- The IT Center is to be perceived as a reliable partner for all user groups.
- The IT Center is an interdisciplinary partner.
- The IT Center strengthens its customer orientation.
- The processes at the IT Center are optimized and there is an increase in transparency and liability towards the users (Bischof, Hengstebeck & Grzemski, 2011).

As part of the establishment of ITSM the IT-ServiceDesk was opened in 2010 as the central point of contact for all inquiries regarding the IT services of the IT Center. It is responsible for responding to defined inquiries as well as for coordinating the communication between users and specialist division involved in more complex queries.

Through the establishment of the IT-ServiceDesk as a ‘Single Point of Contact’, it was possible to meet the users’ request for high-quality IT support. In order to highlight and maintain a high support quality the IT-ServiceDesk was successfully certified according to the DIN ISO 9001:2015 standard in 2016 (Pieters, Hengstebeck & Grzemski, 2017). This certification confirms that a quality management system has been operated successfully and developed further.

The current 1st- and 2nd-level support structures are focused on service provision for members of RWTH Aachen University.

Due to emerging changes (Deutsche Forschungsgemeinschaft, 2016; Wissenschaftsrat, 2015a) in the academic landscape in North Rhine-Westphalia (NRW) and all of Germany, different services – for example HPC (high-performance computing) – will be consolidated. Because of this, the IT Center is striving for more closely knit collaborations with the ZHV and the UB of RWTH Aachen University. This will promote a strong common representation and positioning in the country. The goal is to act as a reliable collaboration partner both within RWTH Aachen University and with other interested research institutions. Already established support structures and services must be adapted and further developed according to these new requirements.

The focus of this article lies in the adaptation of support structures within the context of partnership with ZHV and UB as well as external research institutions. Besides some implications regarding financial aspects and challenges are addressed only marginally because these are not the focus of this paper.

3. DEMAND FOR MORE COOPERATIONS

The development and operation of IT services is becoming increasingly complex. In order to operate and develop an IT service with a defined quality of service ample resources are needed (in addition to the relevant technology, personnel with the appropriate qualifications). At the present time, a large number of university computer centers operate all necessary services themselves. Ultimately, this has a negative effect on the quality and availability of the respective services since the necessary resources can often not be provided with the required quality.

It stands to reason to focus competencies on a few specific services and offer them with an excellent quality instead of trying to provide all services and only being able to do so with lesser quality. Services that as a result can no longer be operated by a university are then obtained from other organizations that have focused their expertise on these. In this way the individual university computer centers form centers of competence for specific services and make use of services offered by others. Focusing on specific services thus builds a high level of know-how of the operation and further development of these services.

Not only have the computing centers themselves recognized that it is neither effective nor efficient to operate all services themselves. The Commission for IT Infrastructure (KfR) of the Deutsche Forschungsgemeinschaft (DFG) recommends a sustainable IT strategy in the opinion piece ´Informationsverarbeitung an Hochschulen – Organisation, Dienste und Systeme´ (Deutsche Forschungsgemeinschaft, 2016) and states that required IT services do not necessarily have to be supported by the local computer center but can also be obtained from external service providers:

´Die interne Optimierung von Prozessen, Organisationsstrukturen und inhaltlicher Ausrichtung der Hochschulen […] führt typischerweise zu hochschulspezifischen Lösungen beim effizienten Einsatz von IT. Dieser Prozess kann jedoch nicht an den Grenzen einer Hochschule aufhören.´ (Deutsche Forschungsgemeinschaft, 2016)

In addition to the Deutsche Forschungsgemeinschaft (DFG), also states in its 'Empfehlungen zur Finanzierung des Nationalen Hoch- und Höchstleistungsrechnens in Deutschland' (Wissenschaftsrat, 2015a) that cooperative structures must be created. Moreover, future high-performance computers will also be available for nationwide use. This will result in an increase of the user groups which requires the support from the universities running a computing cluster.

These requirements are taken into account by RWTH Aachen University in their IT concept (RWTH Aachen, 2016). It is noted that the university or the three central IT service providers will be working as service providers for other universities and research institutes.

Such collaborations have already existed rudimentarily for some time. For example the University of Paderborn has been using RWTH IT Center's backup and archive service for several years. The IT Center also runs the Exchange infrastructure at the University of Paderborn.

In a pilot project the IT Center provides the central Exchange infrastructure for the employees of the universities of the Fine Arts at the Essen location.

In this model the external institution acts as a 1st-level support entity for their users, sometimes there are also external specialist division which act as 2nd-level. Accordingly, the IT-ServiceDesk or the IT Center (specialist division) then becomes the 2nd or 3rd-level support unit. The orange arrows shows the escalation leves the queries can take. The green arrows describe answering paths. To point to the blue arrows, they describe how the communication and hence the answers are forwarded from the local to the external institution or external users. A particular variation shows the green arrow that illustrat that the specialist division IT Center comunicat to the external specialist division. For technical reasons this procedure may be helpful.

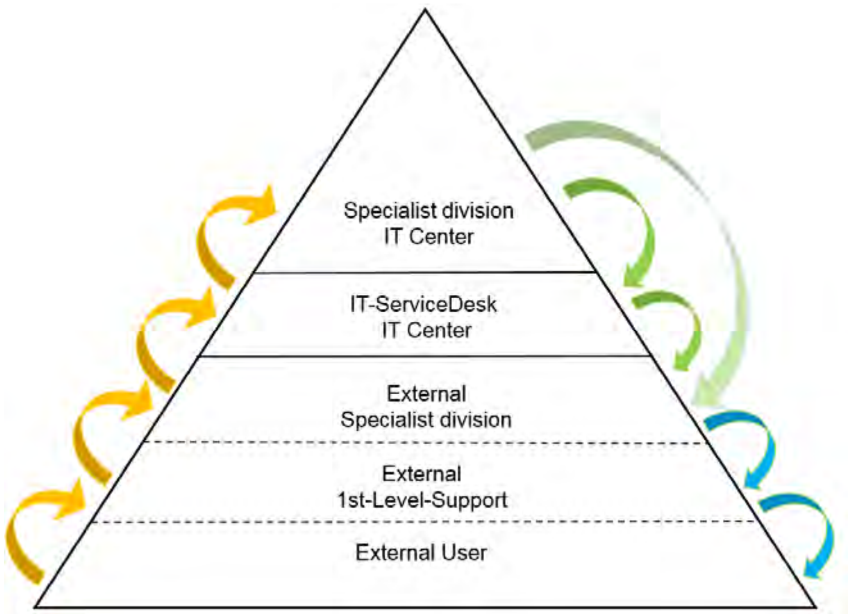

Illustration 1: Support pyramid: Exchange

In cases where the IT Center receives services from other universities or research institutions the support structure is as follows. A successful example of this kind of partnership is the service Sciebo of the University of Münster (Sync & Share NRW, 2017).

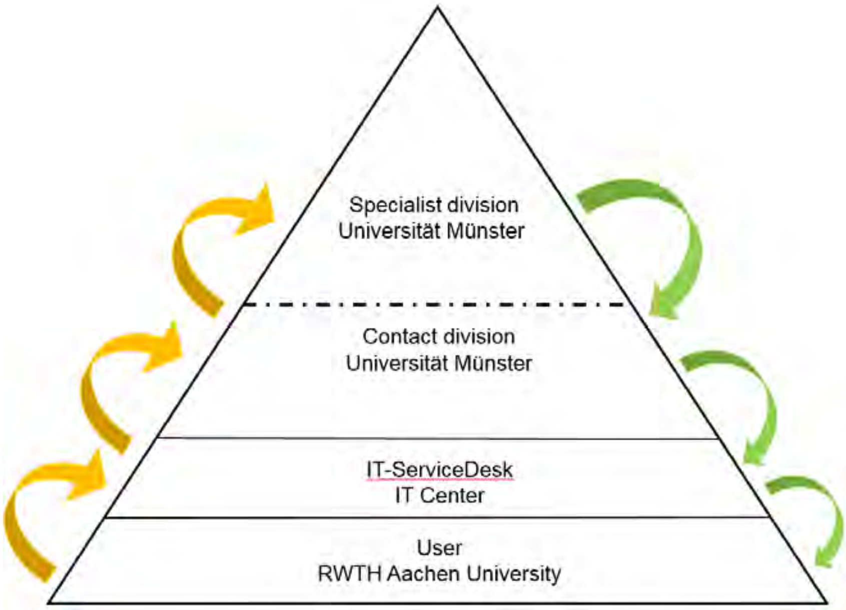

Illustration 2: Support pyramid: Sciebo

Here, the local computing center (IT Center) offers its users the Sync and Share service 'Sciebo' which is provided and further developed by the University of Münster. This service can be used by all members of RWTH Aachen University. The 1st-level support for members of RWTH Aachen University is provided by the IT-ServiceDesk of the IT Center. Inquiries which go beyond the defined 1st-level support are forwarded to the 2nd-level Sciebo-support. The replies by the 2nd-level support will be passed on to the users by the 1st-level support of the IT Center.

4. FUTURE SUPPORT STRUCTURES

The new collaborative orientations of the computing centers imply that the support structures introduced so far have to be transformed in order to be able to continue providing high-quality support. Within this context, it is important not only to take into account the fact that external institutions of higher education and research may use services, but also that different services within the university may be provided by different institutions and/or external partners. For example, at RWTH Aachen University, the new Campus Management system was conceived jointly by all institutions involved in the university (faculties, ZHV, UB and the IT Center) and launched together with the implementing external partner.
Another example is the research data management (Wissenschaftsrat, 2015b) which is required by a new legal framework. This is provided jointly by the UB, the Research and Career Department, as well as the IT Center of RWTH Aachen University.
Noteworthy is a cooperation with the Forschungszentrum Jülich where the Eduroam device management system is being designed.

These three examples are presented below in regard to their challenges for the support structures.

4.1. New scenarios in IT support

As already described, it is necessary to transform the existing support structures in order to ensure high-quality and customer-oriented support in light of new requirements. In the following, new support scenarios are described using three short case studies.

1. **Interdisciplinary service for coordinating and organizing student lifecycle and teaching (example Campus Management System)**

   Within the context of the establishment of a new Campus Management System (RWTH Aachen PuL-Projekt, 2017) for the organization of the student lifecycle and teaching the existing support structures must also be adapted to accommodate the large number of institutions involved (Student Office, Central Examination Office, IT Center, Departmental Student Adviser etc.). Until now, users had to address their queries directly to one of the above-mentioned institutions but it was not always clear which institution could answer the question. As a result, they were often referred from one institution to another. In order to avoid this in the future, all queries relating to the new campus management system are to be directed to one central address. All participating institutions can access these requests, for example via a common ticket tool. The challenge here is introducing the ticket tool to all institutions that have not used it so far. They may be skeptical and lacking expertise in using it.

2. **Interdisciplinary service for the scientific community (example: research data management)**

   These services are provided not only by the local computing center but also in cooperation with other institutions of a university. At RWTH Aachen University, for example, the research data management is collaboratively provided by UB, the Research and Career Department and the IT Center (RWTH Aachen Forschungsdatenmanagement, 2017). The IT-ServiceDesk serves as a single point of contact for all inquiries regarding research data management. Accordingly the IT-ServiceDesk is responsible for answering defined standard requests. More sophisticated inquiries are forwarded to the appropriate institution. Currently, users are receiving a solution from the responsible institution at RWTH Aachen University directly, rather than via the IT-ServiceDesk.

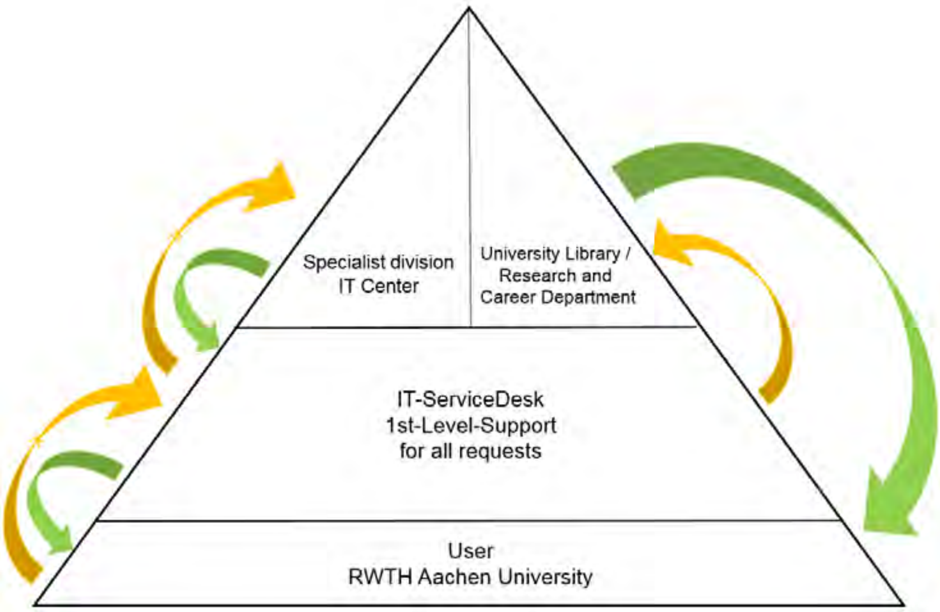

Illustration 3: Support pyramid structure: research data management

3. **Joint conceptualization and development of a service between two mutually independent institutions (example: Eduroam Device Management)**

   The local computing center and an external research-oriented partner organization are designing and developing a service (both technically and organizationally). This is then provided and operated by the local computing center. Further development of the service would happen in collaboration with the other institution. If the service was to be offered to additional institutions they might become involved in the further development as well.

   One example is the Eduroam Device Management which was developed by the IT Center and Forschungszentrum Jülich. This is an application to create and manage device-specific Eduroam identifiers. Before the introduction of this application, users often chose the same password for their Wi-Fi/VPN account and other RWTH accounts. The new Eduroam Device Management generates individual Wi-Fi credentials for each device (Decker, Politze, 2017).

This increases the security of other RWTH service accounts because they would not be affected if Eduroam access data were compromised by a identity theft. Furthermore, existing Eduroam login credentials can be deactivated individually and immediately if a device is lost.

The idea for the Eduroam Device Management was developed at the IT Center. It also carried out a first implementation for the members of RWTH Aachen University. In discussions with Forschungszentrum Jülich, the research center expressed its own need for such an application. To ensure that it would not have to invest its own resources in the development of such a system, the service was collaboratively developed. Now, other external institutions could use this service as well. The service and thus the support concept are currently still under development but probably it will be guided by illustration 4.

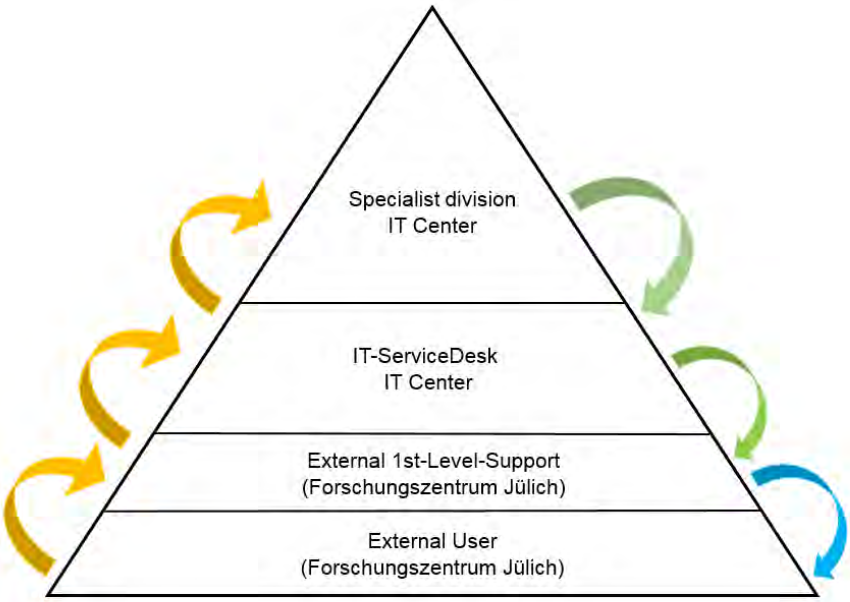

Illustration 4: Support pyramid Eduroam Device Management

4.2. Challenges of the new support scenarios

The aforementioned scenarios present several new challenges to the 1st-level support. These can be classified as follows:

1. Formal challenges
2. Work organization and communicative challenges
3. Technical challenges

Formal challenges:

For all three scenarios it is necessary to establish in addition to default servicelevel agreements (SLAs) service description and special support agreements between the participating institutions in which the following points are taken into account.

The agreements must indicate at which institution which level of support is located or whether a division of support will take place. For example it would be possible that the 1st-level support is located at the utilizing institution and only requests which go beyond previously defined 1st-level support are passed on to the providing institution. In this case it would become necessary to define precise limits between the 1st and 2nd level support.

In general, it must be determined whether support requests which are passed on to the university providing services are billed individually or whether they are charged at a flat rate. If billing was defined according to the number of requests a reliable and transparent reporting would have to be put into place for accurate billing. Furthermore reporting is also required for documentation and quality assurance.

In addition to the precise definition of support responsibilities it is necessary to define contact persons. It should be noted who is entitled to make inquiries to the service provider. It is also important to determine the ways in which requests are exchanged between the institutions and how they are documented. The use of a ticket system is a particularly big challenge here.

To ensure that all requests are processed in a timely manner, appropriate escalation times and procedures must be negotiated between the participating institutions.

Further formal challenges is the consideration of data protection. Especially when full support is provided by the service provider, it might be necessary to access users' personal data in order to guarantee high-quality support. The responsible data protection officers are to be involved here and it needs to be clarified whether and which data can be used and provided for the support.

At the organizational level it is necessary that quality management or quality assurance is incorporated. This can be ensured through regular exchange and review deadlines as well as coordinated reporting. If quality management and assurance processes already exist it is essential to expand these accordingly. In the context of quality management it must also be ensured that maintenance (for example deployment of hotfixes and patches) and changes are communicated at an early stage. Essentially for updates it is necessary to create a release management and fixed release plans which are coordinated in advance. The one-time negotiation of the support framework conditions is not useful as a review and adjustment must take place at regular intervals in order to ensure a high quality.

Organizational and communicative challenges

In addition to the formal challenges, work organization and communication challenges arise. For example, it must be taken into account that there is an increased workload for support staff since now not only the local users make inquiries but also users or defined contact persons from other institutions. In this case, the staff has to know or understand who is eligible for support from the external facility. This can only be achieved by keeping the process documentation up-to-date. Furthermore it is absolutely necessary to design a model oriented training program for the local and also the external institution.

It must also be agreed how the support documentation is maintained – whether a central documentation platform for all participating institutions or individual documentation for each institution is kept.

In addition to the documentation, marketing must also be coordinated. The following questions need to be clarified:

1. Is there any central marketing by the service provider?
2. Through which channels will the service be advertised?
3. Are marketing documents provided centrally?
4. Is a corporate design required for the service?

Furthermore participating institutions may have different support times. These times might, for example, be restricted by internal organizational factors (such as events, meetings, etc.). Such restrictions must be appropriately communicated and discussed ahead of time and might be part of support agreements.

The greatest communication challenge, however, is to highlight the benefits of such collaborative services to staff and users. It must be clear to everyone involved that rather than taking something away from someone, a high quality of IT services can only be achieved by close collaboration. It is therefore necessary to create a common understanding for the importance of working together.

Technical challenges

The technical challenges can be divided into two themes. Technical solutions must be created that allow interactions between the participating institutions to be exchanged without media breaks. Only in this way a high quality of support and its documentation is possible. The experience with the service 'Sciebo' has shown that it is not ideal to forward support requests from the 1st-level support via emails sent through the ticket tool to the 2nd-level support as this causes media breaks.

Due to the use of two different ticket tools in the local 1st-level support and the external 2nd-level support incidences occurred in which a second inquiry from the 1st-level support to the 2nd-level ticket system could no longer be assigned to the original request. This happened because the 1st-level support ticket system removed the ticket number of the 2nd-level ticket system from the subject of the email. So far no automated technical solution could be implemented to fix this. As a result only a manual workaround is possible:

If the 2nd-level support answers a request by email the latter must include the ticket number of the ticket system in the email text. When the 1st-level support responds to this request the ticket number from the email text must be entered into the subject of the email to the 2nd-level support. This is currently the best available way for the 2nd level support to track the history of a request.

This example shows that the exchange of inquiries between two institutions can be quite challenging. Due to the large number of different ticket systems it is necessary to clarify in advance whether a smooth interaction between them is possible. If this is not the case it becomes necessary to provide appropriate technical solutions. Generally, the usage of as limited a number of different tools as possible should be sought.

In addition to the described technical interaction, administration and monitoring tools must be provided for the 1st-level support depending on the specific nature of the support. In the case of the Sciebo service an administrative interface is provided to the 1st-level support units of the participating institutions through which simple activities, e.g. the creation of project boxes can be carried out. To simplify authorization management this interface is linked to the identity management of the participating institutions.

For the service Eduroam Device Management which is operated by the IT Center of RWTH Aachen University and will be made available to other institutions in addition to Forschungszentrum Jülich, administration and monitoring tools will be provided for every 1st level division of these institutions.

5. CONCLUSION AND OUTLOOK

Due to the service provision for external institutions as well as for collaboratively provided services within the university the existing support structures have to be adapted under formal, organizational and technical aspects. Organizationally the existing processes must be modified in such a way that the external users are also taken into account and clear responsibilities are defined. At the IT Center and the IT-ServiceDesk lots of innovations regarding the ´formal challenges´ have already been implemented internally e.g. support agreements. This means that support agreements between the IT-ServiceDesk and the specialist division have been drawn up and are being reviewed at regular intervals by the quality management of the IT-ServiceDesk. In other computer centers that also work in a process-oriented manner similar processes or procedures should exist. Extending these processes to external customers requires only minor adjustments to the processes and, if necessary, professionalization.

The adjustments in the field of billing become more complex if support requests are billed individually. In this case it is necessary to develop corresponding billing models that take into account how the 1st-level support and the 2nd-level support of the service provider is calculated. The development of a transparent billing model by the IT-ServiceDesk is ongoing. So far, transforming the support structures has been prioritized.

Regarding technical aspects, the necessary adjustments also have to be taken into account (among others) because appropriate administration and monitoring tools must be provided for each service that is to be provided externally. These have to be linked with the identity management of the utilizing institution. It should be borne in mind that not only tools for support are provided but also for the users' self-service applications.

The IT-ServiceDesk of the IT Center at RWTH Aachen University addresses the challenges described above. However, in order to face the challenges laid out in this article in the best way possible close cooperation between all participating institutions is crucial. Only through intensive communication between all parties involved can a transparent and quality-assured support with a high service quality for users be ensured.

In addition to the cooperation with the external institutions the IT-ServiceDesk also needs support from the specialist departments within the IT Center to implement technical solutions for the support itself as well as for the services.

Thanks to the work done so far by the IT-ServiceDesk it has been able to meet these challenges and develop itself further in order to support cooperative and collaborating IT services. However, this is associated with major changes that cannot be implemented quickly but must be introduced step by step in order to keep the burden on all parties involved low.

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7. AUTHORS' BIOGRAPHIES

Sarah Grzemski studied Economic Geography, Economics and Geography. She received her Master's degree from RWTH Aachen University in 2002. Until 2007, she worked as a research assistant in the Department of Economic Geography of Services. Her main research focus were employees in call and service centers. Since 2007 she has been working for the IT Center of RWTH Aachen University. Initially, she worked for the division of Process IT Support. In 2010 she was made devision head of the IT-ServiceDesk. In this role, she assumes responsibility for the staff and strategic development of the IT-ServiceDesk, particularly with regard to customer support and service to the present day.

Ingo Hengstebeck studied Technical Communication. He received his Master's degree from RWTH Aachen University in 2009. Until 2009, he worked as an employee at the IT Center. Since 2014 he has been the deputy division head of the IT-ServiceDesk. His work is focused on quality management, process management and communication in the field of user support.

EUNIS 2017: How to make money with HE IT

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Helsinki Metropolia University of Applied Sciences, Finland

Keywords
budget, money, resources, collaboration

Abstract

Currently in Finland the pressure to get more and more funding outside from public funding is rising. This paper presents Metropolia IT's current means to fund part of its existence. Presentation concentrates how support services are earning money to Metropolia.

1. Introduction

Metropolia's need to optimize its current resource usage still remains, as the Finnish financial climate hasn't really changed to positive direction during last couple of years. In year 2009 Metropolia's IT department earned about 85000€ as income from the sources outside of the university. In year 2016 Metropolia's IT department earned about 546000€ as income from the sources outside of the university. How we are earning the money and why are we earning?

2. Previous years and the development to current situation

In year 2009 funding was flourishing for higher education and for Metropolia's IT-department. Operation budget was 4.4M€ with estimated 45000€ income and investment budget was 2.2M€.

In year 2011 Metropolia held "IT-päivät 2011" conference which created a lot of extra revenue for that year. When removing that income from picture above we can see that we have been able to grow our outside income steadily to current point.

Answer to why to do it is below. We are not doing this only because our management is expecting that or that we are instructed to do so.

- Part of income is coming from selling our specialists and this outside work is improving their knowledge, and that way it adds their value to the university.
- We also believe in recycling and that is the reason why we are not sending old equipment to recycling companies, but we are selling them to students with reasonable prices. This also ensures that our students have equal chance to have a pc to support their studies at their homes.
- We have also hired our students as trainees to do the hard work for upgrading our teaching environments equipment during summertime and that way we are ensuring that those students

able to do their work placement during studies and to reach 55 ECTS units which is the yearly limit to get the funding from the government.

- A work placement in Metropolia's helpdesk is also ensuring that they have a chance to be employed after graduation which government is also rewarding after graduation.

So, it is really based on that little strokes fell great oaks.

The how we are doing it will be told in presentation.

3. Current situation and the future

For year 2017 budget framework is 3.7M€ for operations and 2.7M€ for investments plus the budgeted 0,7M€ income. Which means that if we do not reach that income at all we will only have 3,0M€ operational budget and from that the salaries are about 2,4M€.

My plan is to continue to advertise our knowhow as it is just stupid to try to invent the same wheel again simultaneously. More we do together, more we have resources to concentrate to the competitive things.

AUTHORS' BIOGRAPHIES

Mikko Mäkelä, IT-service manager from Metropolia's beginning 2008. He also has been teaching for last 15 years as part time teacher in Media and ICT degree program. Public LinkedIn Profile: http://fi.linkedin.com/in/mikkoim/

EUNIS 2017: Future ways of ~~Teaching~~ Learning

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Keywords
Technology, Learning, Future, Teaching, Design, Environment, Solutions, Outcomes, Collaboration, Comfort, Aesthetics, Spaces, Innovation, Consultant, Connected, Interactive, Pedagogies, Networked

1. SUMMARY / ABSTRACT

This paper explores what really needs to be considered when designing technology for the next generation of learning spaces. The intention is to fuel a conversation that might eventually change the thought processes behind technology design within higher education. In fact innovation would likely occur more rapidly if consultants were driven by an alternative set of variables when investigating options and designing solutions. Ironically, taking the focus off technology momentarily in favour of focusing on the core objective – improving learning outcomes; would encourage a more collaborative approach to client interaction. This would inturn become a major catalyst for the design of more effective solutions that improve learning objectives.

2. INTRODUCTION

In order to understand the role that technology should play within a learning space one must first understand what is a learning space. A learning space encompases all spaces where the learner undertakes some form of study or learning and other spaces inhabited or customized by the learner, with students moving through a variety of learning spaces on any given day.

Learning spaces can be defined as –

- Physical, blended or virtual learning environments that enhance learning;
- Physical, blended or virtual 'areas' that motivate a learner to learn;
- Spaces where both teachers and learners optimize the perceived and actual affordances of the space;
- Spaces that promote authentic learning interactions.

The next generation learning spaces may vary, but typically they enable new pedagogies, including technology enabled pedagogies, to be explore and trialed. They are intentionally designed to facilitate collaboration, connection and active learning. They also allow for students to use their own devices. They might include formal and informal spaces, physical and electronic spaces and have comfortable furniture that is configured easily and quickly by academics and students to suit different pedagogies.

3. PRINCIPLES OF LEARNING SPACE DESIGN

There are 7 principles of a learning space design which support a constructivist approach to learning and support a learning environment that is student-centered, collaborative and experiential. The development of these principles explicitly embrace the student voice.

The Spaces for Knowledge Generation design principles comprise:

1. **Comfort**: a space which creates a physical and mental sense of ease and well-being
2. **Aesthetics:** pleasure which includes the recognition of symmetry, harmony, simplicity and fitness for purpose
3. **Flow**: a state of mind felt by the learner when totally involved in the learning experience
4. **Equity:** consideration of the needs arising from cultural and physical differences
5. **Blending:** a mixture of technological and face-to-face pedagogical resources
6. **Affordances:** the 'action possibilities' the learning environment provides the users
7. **Repurposing:** the potential for multiple usage of a space

To facilitate connected, active learning in a social context, we need to develop a range of spaces where small groups could meet to work on projects as well as encourage whole-class dialogue. Where technology can be accessed easily to display ideas and working documents as well as accommodate movement and noise. There should also be spill over spaces in corridors and lobbies.

Aligning pedagogical, technical and administrative issues is also a necessary condition of success for creating an engaging learning environment. Almost all academic authors that explore this topic agree that next generation learning spaces are intentionally designed to facilitate collaborative and interactive learning. Whilst some believe that we need to move beyond collaborative learning to spaces that enable new pedagogies to be explored and trialed.

Universities across the world have invested billions of dollars in the building next generation learning spaces. In some cases, the investment is prompted by the belief that such infrastructure will:

- Foster the university's reputation as 'cutting edge';
- Give the university a competitive edge in attracting students;
- Support the university to teach increased student numbers; and
- Support the university to cope with tight funding situations.

If next generation learning spaces are to deliver on these expectations, the learning and teaching activities conducted in them need to engage students and be tailored to help them achieve intended learning outcomes.

4. THREE LEGS ARE BETTER THAN TWO

There are three components that need to work in unicen to create the necessary environment for effective learning – pedagogy, the space and technology. Each leg is equally important, without one, the stool falls over and learning objects are not achieved effectively.

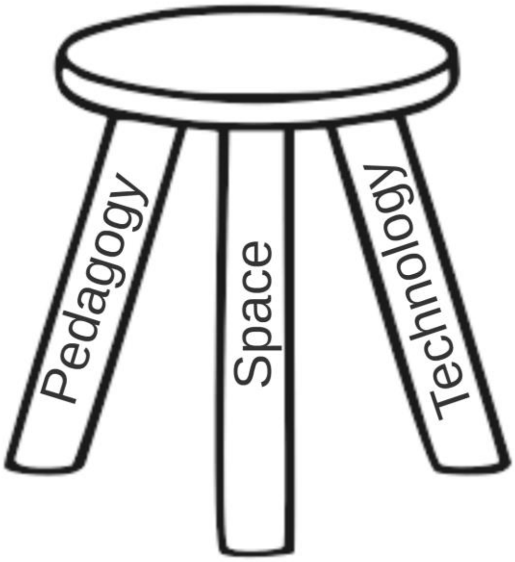

Figure 1

The learning design needs to utilize:

- Interactive learning (learner-to-content),
- Networked learning (learner-to-learner, learner-to-teacher),
- Learner-generated content (learners-as-designers),
- Connected learner approaches (knowledge-is-in-the-network) and assessment-as-learning

However it's not uncommon for spaces to be designed for lecturers or for the purpose of collaboration only to have teaching staff continue to teach as they have always taught (and as they had been taught). However, if technology consultants and designers are to deliver learning spaces of the future they need to start asking more questions like –

- What attributes do students need to be successful?
- What roles will students and staff play in these new spaces?

Likewise, a learning space needs to be underpinned by the pedagogy -

- What pedagogies are appropriate in next generation learning spaces?
- What assessment tools are required?

Moreover, if more consultants start asking these questions in order to gain an indepth understanding of the holistic teaching environment, then innovation within the learning space will be the logical progression. Achieving and improving learning outcomes trumps wow factor and creates a long term competitive advantage. Ask the right questions, get the right answers.

5. COPYRIGHT NOTICE

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7. AUTHORS' BIOGRAPHIES

Peter Coman is multi award-winning designer whose career spans 25+ years in the technology

industry. With a background in owning and managing IT companies and installing and programming advanced technology systems, Pete knows what it's like on both sides of the fence.

As a result Peter tours the world attending and speaking at many industry events, and is considered as a thought leader amongst his peers.

He also likes long walks on the beach, eating out, watching the footy, and has a passion (bordering on obsession) for technology.

"Peter is able to take concepts and ideas from non-technical staff and make them a reality through thoughtful, considered design. He researches what is required and marries that with what is available in the marketplace to produce an up to minute solution."

Dr Ruth Greenaway
PhD MLM BA Grad Dip Ed, Academic Developer
University of the Sunshine Coast

"Peter is one of the most passionate people I know in the AV world. His enthusiasm and keen awareness of the industry are both refreshing and inspiring."

Scott Wills, CTS-D, CTS-I
Senior Director of International Member Services
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"Peter provides insight into the possibilities with innovative designs and inspiration. Works as part of the team not just a business partner."

Owen Cuthbert
Project Manager
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"I have known Peter almost twenty years and his attention to detail is second to none. Peter's diversified technical assistance and motivational skills have aided in many ways to the expansion and success of our organisation of 25 years. Peter has a thirst for cutting edge technology and his passion for perfection flows into his business solutions. Peter continues to be an asset to our business but above all a good mate."

Stephen Wisby
CEO & Founding Partner
AWR Group Pty Ltd

“Peter is an outcome focused consultant with a high attention to detail who is uniquely experienced and well qualified in the area of merging technologies. I know Peter to be passionate about his industry and professional in all dealings.”

Jason Derry
Executive Director
VIDEOPRO

Our company provides solutions for high quality computer video signal processing, distribution and switching. But, a strong understanding of video theory is often needed at a design level, to implement many of our products and proficient people in this field are hard to find.

Peter has proven to be just one of these people, with an advanced understanding of video signals and has demonstrated some extremely high level commercial video designs.

He's also a likable guy and I'd happily recommend Peter for anything he chose to become involved with.

Jerry Kushnir
Looking for opportunities. - Highly experienced AV Systems designer, sales engineer, trainer, technical troubleshooter.

Peter Coman is an "ideas man". But that being said, it's his attention to detail and his understanding of why standards are important that make him so effective.

Paul McDow
Business Development Manager
Acer Computer Australia

“Peter is an innovative and forward-thinking technologist. He has a high level knowledge of a wide range of IT, AV and building services systems and understands how to integrate them all seamlessly to deliver sophisticated solutions to his clients.”

Paul Stathis
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Winner - 2017 InAVate International Project of the Year – Tasmanian Department of Education – Professional Learning Institute

Winner - 2015 AVIA – Best application of AV in an education project with a budget under $500,000 – University of the Sunshine Coast

Winner - 2015 – Crestron – Education Project of the Year - University of the Sunshine Coast

Finalist - 2015 InAVate International Project of the Year – University of the Sunshine Coast

Finalist - 2014 AVIA – Best application of AV in an education project with a budget under $500,000 – University of the Sunshine Coast

Finalist - 2014 AVIA - Best application of AV in an education project with a budget exceeding $500,000 – University of the Sunshine Coast

Winner - 2011 BICSI South Pacific Project of the Year

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- Crestron – Digital Media Certified – Engineer (DMC-E)
- Siemon Certified Designer - Copper & Fibre
- ADC Krone Master Installer - Copper & Fibre.
- Molex Certified Installer - Copper & Fibre
- Assoc IES - Illuminating Engineering Society
- BICSI - Electronic Safety & Security Designer (ESS)
- NSW Security License - Class 2ABF Seller, Consultant, Equipment Specialists
- Queensland Security License - Class 2 Adviser, Equipment Installer

Professional Association Memberships

- InfoComm – The Audio Visual Association
- BICSI – Global association supporting designers and installers of Information Transport Systems
- AFCOM - The leading association of data centre & facilities management professional
- IEEE - Institute for Electrical & Electronics Engineers
- ASIAL - The Australian Security Industry Peak National body
- IES - The Lighting Society

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Implementation of the Research Core Dataset at universities in North Rhine-Westphalia – An approach of a federal initiative

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Keywords
CRIS.NRW, Kerndatensatz Forschung, Research Core Dataset, Research reporting, North Rhine-Westphalia

1. SUMMARY

In January 2016 the German Council of Science and Humanities (Wissenschaftsrat) published the specification of a core data set on research activities and recommended a nationwide realization within the german science system. To serve this recommendation the federal state North Rhine-Westphalia (NRW) established the federal initiative CRIS.NRW. This paper describes the aim and approach as well as recent activities and their results to succeed and enhance structures of communication and support for the implementation of the Research Core Dataset at universities in NRW.

2. INTRODUCTION

Research institutions are mostly faced with several internal as well as external reporting obligations. They have to gather different data regarding research activities for different occasions such as information needs for funding organizations, rankings and statistics as well as internal information needs. Furthermore the importance of acquisition and reporting of research activities and their results have constantly grown over the past years.

Especially in the German sciene system there are no existing general standards for the collection and processing of research information (Biesenbender & Hornborstel 2016). For this reason the effort to provide the necessary information of these diverse reporting purposes and obligation are often very high for universities. To reduce this effort, an approach to standardize the data definition, collection and reporting of research activities has been made by the Wissenschaftsrat. In January 2016 the Wissenschaftsrat published "Specification of a core data set on research activities", the so-called "Research Core Dataset" (RCD), and recommended a nationwide realization within the German science system (Wissenschaftsrat 2016, Biesenbender & Hornbostel 2016).

In Germany, higher education policies are regulated by the individual federal states. Therefore, the federal initiative CRIS.NRW was established in May 2016 to implement the Research Core Dataset at universities in the federal state of NRW.

3. AIM AND APPROACH

The main aim of CRIS.NRW is to establish central structures of communication and support for universities in NRW to implement the RCD and if necessary tools to accomplish the realization, like current research information systems (CRIS). In general a CRIS is described as a database or information system, which collects, manages and provides research information within research institutions (Ebert et all. 2015; Herwig & Schlattmann 2016). With its possibilities to aggregate research information it supports the reporting of research activities.

The activities within the scope of CRIS.NRW are structured in three parts (see Figure 1). Summarized the activities serve the purpose to connect the universities in NRW to enhance the information and experience exchange, to guide and support the universities individually and to coordinate a shared understanding as well as the harmonization of the research reporting system in NRW.

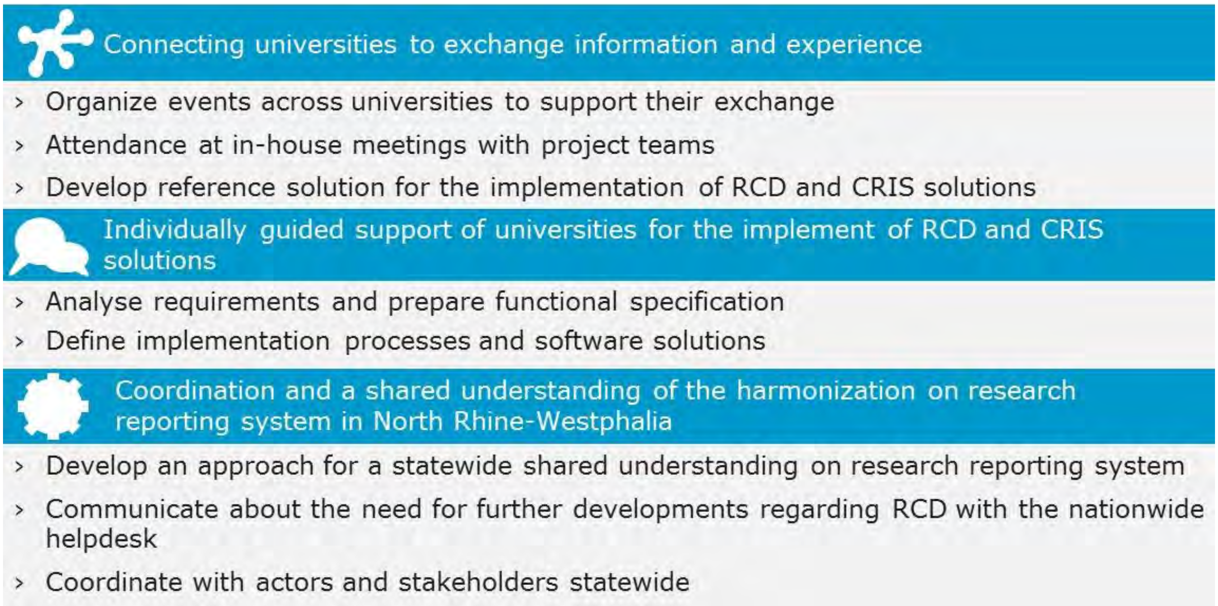

Figure 1: Work Packages of the project CRIS.NRW

Overall CRIS.NRW pursues a statewide common agreement of the definition, collection and provision of data regarding research activities. With its approach CRIS.NRW aims to take an important part in the coordination and harmonization of the research reporting system in NRW as well as a valuable mediator for universities and the Ministry of Innovation, Science and Research of NRW.

4. ACTIVITIES & RESULTS

CRIS.NRW made serveral efforts since starting the project in May 2016. The activities were chosen to fullfile the purpose to get to know the universities, especially the persons in charge, and their needs to implement the RCD. The results are also used to adapt and strengthen the structures of communication and support to the demands of the universities.

Survey about Research Core Dataset

CRIS.NRW started by conducting and evaluating a survey that focussed on 30 public universities in NRW (Hochschulkompas 2017). The purpose was to investigate the status quo of the progress universities made concerning the implementation of the RCD. The main focus of the survey were two relevant questions: 1. the status of discussions about the RCD at the university and 2. the value of the RCD at the university. Altogether 25 universities took part in the survey. The results of the survey were used to get an impression about the current status of implementation at the universities and how high the acceptance of the RCD is.

Results

Relating to the status of discussion about the RCD within universities, 23 of the universities consider the RCD as relevant and want to pursue its implementation further (see Figure 2). 11 out of 25 universities have already formed a project team or initiated first steps to do so.

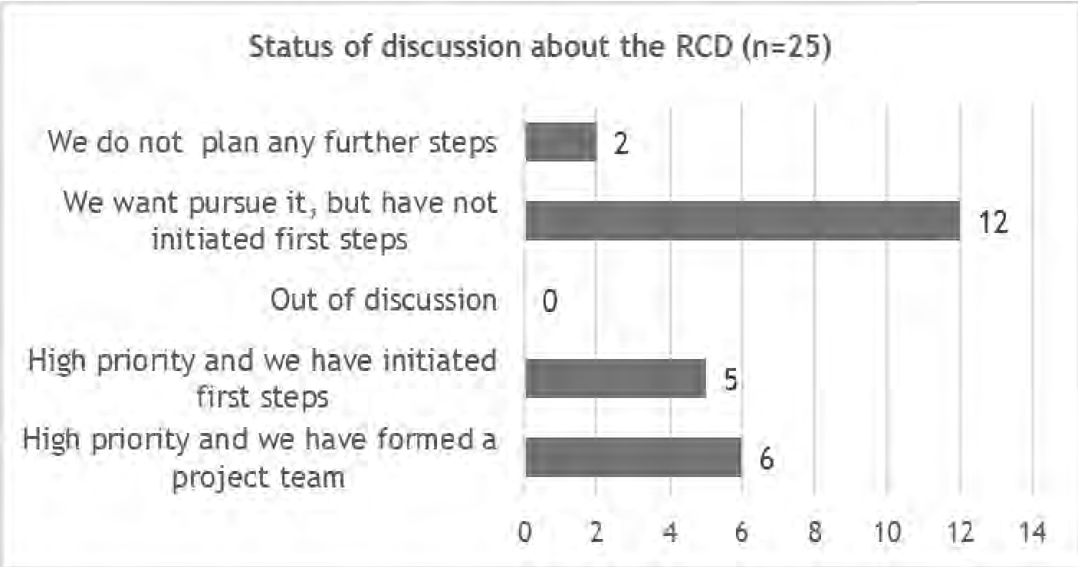

Figure 2: Status of discussion about the RCD

In general the results showed that almost every participating university feels positive about the RCD (see Figure 3). More than half of the universities appraise the RCD as a valueable approach to simplify the research reporting system and to standardize reporting requirements.

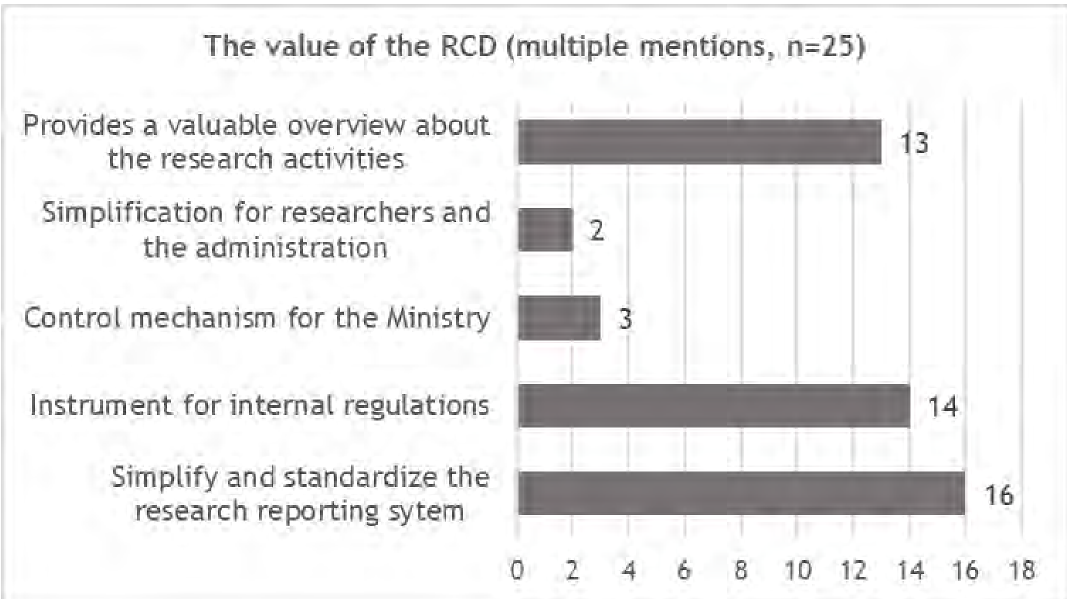

Figure 3: The value of the RCD

Individual meetings and informative events

As first step to create awareness about the RCD and to enhance the assembled structures of communication and support, CRIS.NRW started visiting several universities in NRW. These universities were interested in the approach of CRIS.NRW and/or needed guidance as well as support for the implementation of the RCD and CRIS solutions.

Furthermore CRIS.NRW organized and evaluated an information workshop in January 2017 for university members, explicitly for people, who are operationally in charge to realize the RCD and/or CRIS solutions. The aim was to promote the exchange of information and experience between universities as well as present examples of universities, which are already dealing with the RCD and/or CRIS.

In addition CRIS.NRW concucted a second survey during the information workshop. The main part of the survey were questions and views about: 1. the current status of the realization of the RCD at the university, 2. the aims that were pursued by the university in implementing the RCD, 3. which tools would be used to implement the RCD and 4. the possibilities of a cooperation with other universities. Overall 22 out of 28 participating universities completed the survey.

Results

The results of the survey confirmed the results of the previous survey as well as the individual meetings with a few universities the team of CRIS.NRW had. Regarding the current state of the realization of the RCD, 20 out of 22 universities answered that they are at the beginning of the implementation of the RCD. Only three universities had already made basic decisions, but are still at the beginning of their planning phase.

In terms of the aims the universities pursue in implementing the RCD, over 90% of the universities see an efficient data collection and analysis as well as research reporting as an advantage (see Figure 4). Also more than 80% want to optimize the external presentation about research activities in general and want to help researchers to represent themselves in a better way.

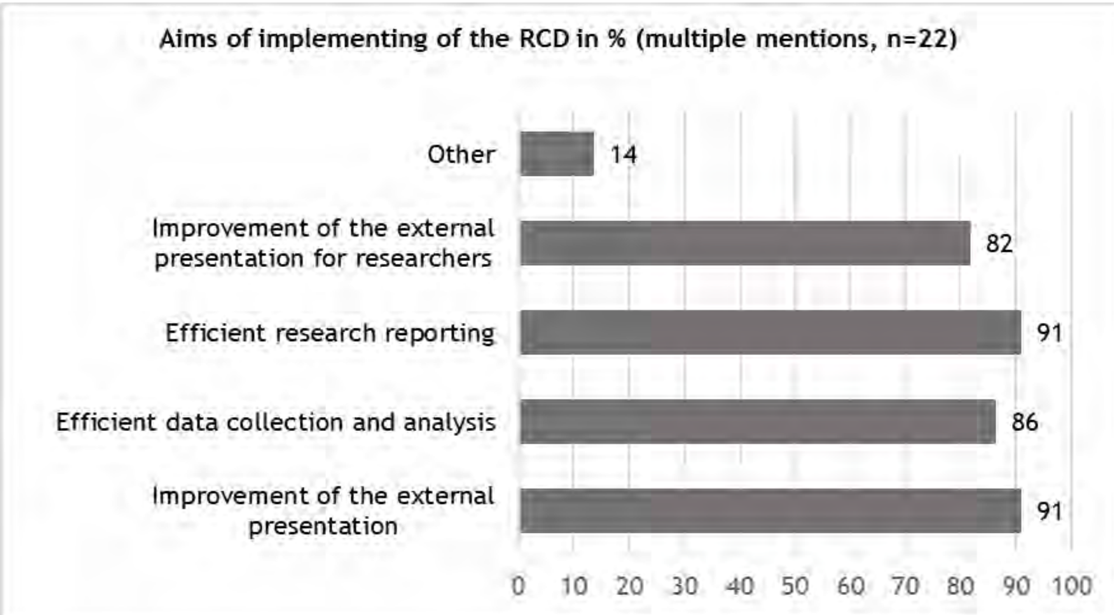

Figure 4: Aims of implementation of the RCD

Concerning the tools they want to use to implement the RCD, 11 out of 22 universities are not sure yet which tool they plan to use. Nine universities want to use a CRIS (commercial and non-commercial) to help implement the RCD. The remaining universities will use their already existing information systems or a data warehouse solution.

The results about potential cooperations between the universities (see Figure 5) show that nearly 70% of the universities are highly interested in a development partnership or would use a configuration of a CRIS from another university.

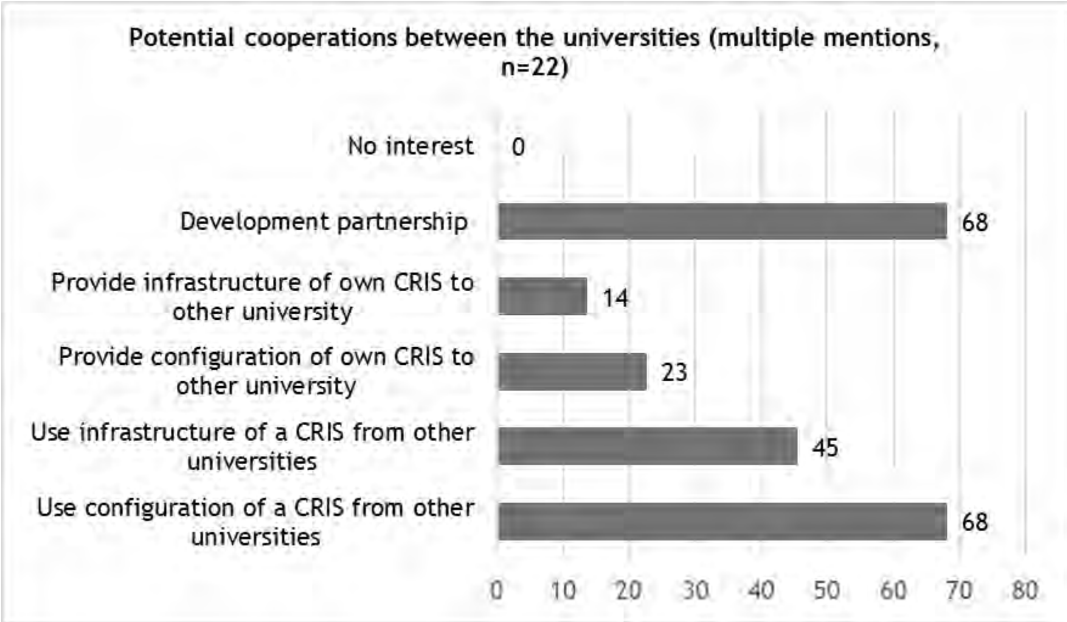

Figure 5: Potential cooperations between the universities

5. CONCLUSION & OUTLOOK

This paper presents the effort of the initiative CRIS.NRW from its start in 2016 to help and support universities in NRW to implement the RCD. The recent activities and their results show that most of the universities are still at the beginning of their intentions to implement the RCD. Fortunately a big part of the universities are highly interested in a common approach to implement the RCD and/or CRIS solutions.

Nonetheless the selected approach was fundamental to get to know the status quo of the universities in NRW as well as their planned attempts in implementing the RCD and/or CRIS solutions. In addition CRIS.NRW was able to adjust their approach and enhanced the structures of communication and support for universities in NRW. Further achievements of the activities can be summarized as follows:

- Got in touch with the universities and the persons in charge by conducting a survey about RCD
- Got to know the (information) needs of the universities for the implementation of RCD/CRIS solutions by doing individual meetings at different universities
- Connecting the universities and responsible persons for information exchange by organizing informative events

Furthermore the initiative took a big step in connecting the universities as well as making the first move regarding the cooperation possibilities between the universities in NRW.

A limitation of this paper is, that the federal initiative CRIS.NRW is still the only initiative in Germany with this approach. Concerning this fact, the authors can only report activities and results that were made within the initiative CRIS.NRW and do not have the chance to compare the approach and the results with other federal initiatives in Germany. But as the approach turned out to be a good proceeding to archieve the goals, it could be used as best practice for other federal initiatives in the future.

The next important step for the team of CRIS.NRW is to develop concepts for a common practice for the implementation of the RCD in cooperation with the universities in NRW. Even if most of the universities are still at the beginning of their attempts, it can be seen as a good starting position. Based on the current level of implementation one concept could be to identify how the universities of NRW can be brought together in usergroups for an enhanced exchange. The goal of these usergroups will be to evaluate a common approach in how to implement the RCD/CRIS solutions and how to develop a common understanding regarding the research reporting system in NRW.

6. ACKNOWLEDGEMENTS

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Don’t be afraid to ask: Implementing "New Absalon

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Title

Don’t be afraid to ask: Implementing "New Absalon".

Keywords

LMS, implementation, project management, change management, process design, organization

1. SUMMARY

This extended abstract describes the acquisition and implementation of a new learning management system (LMS) at the University of Copenhagen (UCPH) from 2014 to 2017. The project is generally acclaimed as a success. The extended abstract describes how success was achieved through a sustained focus on involvement, dialogue, and transparency.

2. ABSTRACT

Introduction

This extended abstract describes the acquisition and implementation of a new learning management system (LMS) at the University of Copenhagen (UCPH) from 2014 to 2017. A LMS is a software application for the administration, documentation, tracking, reporting and delivery of educational courses or training programs. We begin by giving a sketch of the background of “project New Absalon”. Next we outline the various phases of the project. We then proceed to offer examples of how we involved the organization and management in the project. We conclude by clarifying benefits that we reaped by organizing the project around the three keywords: involvement, dialogue, and transparency.

Background on UCPH and Absalon

Founded in 1479, UCPH is the oldest university in Denmark. It is located in four campus areas in central Copenhagen. The university has around 40,000 students and around 10,000 members of staff. It divides into six faculties and around 100 departments and research centers.

The LMS at UCPH is called Absalon. It is considered a business-critical system at UCPH, as it supports one of the University’s most important tasks: education. The name Absalon is a reference to a former Danish Archbishop, and is used irrespective of which particular LMS is used. The name works as a way of 'branding' e-learning at the University. From 2007-2016 the system behind Absalon was Itslearning. In 2016, as part of “project New Absalon” this system was replaced with Canvas, supplied by Instructure. The overall business responsibility for Absalon is located in Education Services (part of the university’s Central Administration). The Central Administration operates all IT systems and services that support uniform practices across the university’s faculties and departments.

In late 2014, management realized that the contract with Itslearning would soon expire (February 2017). Two years is not a lot of time to procure and implement a new system on a large University like UCPH, and UCPH does not have a long track record of fast and successful implementation processes.

A steering committee was organized, and the committee immediately faced a choice: Should the project be organized as a merely technical project, with a fast procurement and implementation process, or should it be organized with an emphasis on a wide-ranging involvement of the organization? Clearly, this would be more expensive and time consuming, but presumably also, in our opinion, lead to a better result.

We opted for the latter alternative and provided a detailed plan for how the project could be organized in such a way. We did this because we believe that the human factor is crucial, and that without organizational buy-in, the implementation of a new LMS would inevitably fail (Kousholt, 2014). Fortunately, the steering committee had faith in the plan that we proposed and the courage to authorize the project design.

Project phases

The project ran from 2014-2017 and comprised four project phases:

1. *A preliminary analysis phase* (business analysis, market dialogue, requirements specification, organizational analysis, etc.).

2. *A procurement phase* (an EU call-for-tenders process).

3. *An implementation phase* (divided into a technical track, where the new LMS, Canvas, was integrated into UCPH's IT landscape, and an organizational track, focused on ensuring that the university's organization would embrace the new LMS at all levels.

4. *An exit phase* (where the former LMS, Itslearning, was phased out, and where the project was shut down ensured a smooth transmission of the responsibility for the new LMS from the project organization to the operations (business) organization.

The below figure offers a sketch of the timeline of the project:

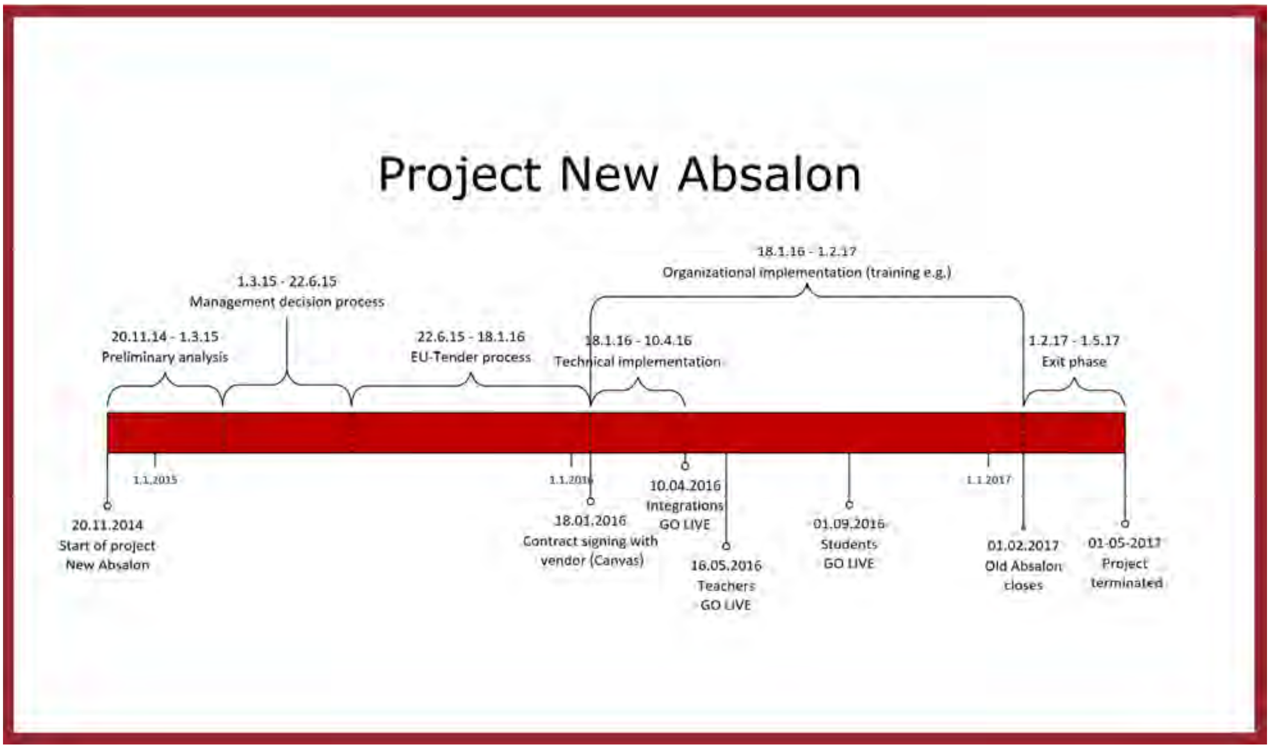

Figure 1: Timeline

Bringing the terms 'involvement, dialogue, and transparency' alive in the project

So how were the concepts of involvement, dialogue, and transparency brought alive in the project? At all times during the project, we aimed to secure maximum participation by stakeholders in the various project activities.

Below we provide four examples of how we did this:

1. In the preliminary analysis phase, we invited both staff and students to submit ideas and requirements for features and technical qualities in the new LMS. We set up an online forum to collect these various inputs.

2. At a later stage, the ideas and requirements we received were discussed and organized by key members of staff in reference groups in such a way that the most important of these could be included in the tender documents.

3. Normally, EU call-for-tenders are a purely ‘written’ process. In this project, though, we instructed the potential suppliers to provide UCPH with access to demo-environments of their LMSs as part of their tenders. When evaluating the tenders, we invited teachers, students and e-learning consultants from all six faculties to test the various systems. At the same time, we asked staff members in University IT to assess the various systems’ technical properties. All views and assessments that were unearthed through this process were included in the final evaluations of the systems, and the winner was chosen in accordance with these inputs.

4. Throughout the project, instead of creating new forums, organizational units, and communication channels, we chose to use the organizational structures and communications channels that were already in place at the university. In this way, we aimed to acknowledge the existing organization rather than placing ourselves in opposition to it.

Besides involving stakeholders to the greatest extent possible, we continually endeavored to facilitate decisions in the steering committee in a way that likewise focused on involvement, dialogue and transparency. On the one hand, we secured the representation of all faculties and key departments across the university in the steering committee. On the other hand, we made sure that every steering committee meeting was well planned and professionally executed, and, even more importantly, that we spent a lot of time communicating on a one-on-one basis with all members of the committee to ensure that they were well informed, involved in and comfortable with all decisions throughout the project.

A thorough stakeholder analysis takes time, but it is a good investment. It made us aware of both friends and enemies of the project (Kousholt, 2012). We deliberately invited potential 'enemies', or skeptics, into the project, because we believed that sometimes 'your enemies are more important than your friends'. Some of these later became our strongest allies. It is a good idea to keep your friends close, but keep your enemies even closer. We also experienced that an individual's strength and influence, at the right levels and at the right time, can be crucial for success.

We consistently aimed to ensure a positive relationship between the organization and the project. If you want to transform an organization you must recognize - and use - the organization as it is (Schein, 1984). We were therefore very attentive to using the structures and groups that already existed in the organization (cf. point 4 above). That way we managed to acknowledge and value the organization and thereby to create a solid basis for a rewarding relationship with the organization. We made sure to design our project process in such a way as to include multiple dialogue-based activities; and when conducting these, we consistently aimed to be explicit (and thus, transparent) about our objectives and the process ahead. We never promised our stakeholders a particular result or outcome; only a transparent, respectful and carefully organized process. And people accepted that.

Another way that we tried to acknowledge the organization 'as it is' was to identify and address the various organizational 'narratives' that we met. For instance, we often heard stories about how the university's Central Administration showed no sensibility to the tasks and needs of the faculties and departments. Whether or not these narratives were true, we acknowledged and addressed them – again, to create a productive and respectful relationship with our stakeholders, thus ensuring that the organization would work with us, rather than against us.

Reaping the benefits

As noted, the project is generally acclaimed as a success. We will end this extended abstract by listing some of the benefits that we reaped by organizing the project around the concepts of involvement, dialogue, and transparency.

- The fact that, from the beginning, we aimed to establish a positive relationship with the organization (for instance, by continuously communicating and inviting people to participate in various project activities) generated a lot of goodwill. This was essential, and meant that we were able to secure the participation in the project of the right people.
- Throughout the project, participants and stakeholders have worked with dedication. According to a recently conducted project evaluation, this level of dedication was a direct result of the way the project was design around involvement, dialogue, and transparency.
- Besides conducting a project evaluation, we have also conducted a survey on user satisfaction with the new LMS. The verdict of both is clear: we got the right system and implemented it on time and budget, and without causing unnecessary vexation and unease in the organization.

It is our understanding that if we had conducted this project as a classic IT-delivery project, we would have met with considerable resistance. Even if we had succeeded in delivering on time and budget, it is unlikely that teachers and student would have received the system in as favorable a manner as in fact they did.

The project reached its goals by taking a consistently communicative and facilitative approach to project management and by sticking to a process design aimed to create and sustain fruitful human relationships and to acknowledge, appreciate, and make use of the university's own various organizational structures.

So in conclusion, we offer the following advice: use the organization - ask away! It may seem expensive, time-consuming, and possibly even tedious at first. But it will be worth the effort.

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An information system perspective on research information systems

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Keywords
Research information systems, CRIS, Research Management

1. Summary

The growing demand of reporting obligations with which universities are being confronted has substantial influence on the perceived relevance of research information systems (CRIS). Although being summarized under the same term, implementations of such systems show a wide range regarding the design and the purpose of use. The fact that there is no shared as well as comprehensive definition for research information systems causes the vague usage of this term. By considering a well-accepted definition of information systems in general, this paper deals with the derivation of applicable characteristics for a CRIS to foster the establishment of a common understanding for this type of information systems.

2. Motivation

What are the main research topics at the university? Which projects are being conducted at the moment? To which extent are results produced within interdisciplinary research groups? Which activities are designated to support the development of young researchers? Due to the growing reporting obligations regarding their research activities, universities see themselves in regular terms confronted with such requests. To reduce the effort as well as to ensure the required information quality, an integrated information management including sufficient tool support is needed. The implementation of research information systems can be seen as proven approach to overcome these requirements (Ribeiro et al. 2016; Sticht 2014). The endeavors of such a project are made difficult due to the lack of a consistent definitional term of a CRIS. Instead in current literature definitional contributions refer heavily to exemplary cases. In this surroundings a CRIS is generally described as database or information system which deals with the collection, management and provision of research information (DINI AG FIS 2015; Jeffery and Asserson 2006; Hornbostel 2006). Thus two main objectives can be derived: (i) harmonization and consolidation of decentralized pools of research information in a central research information system as basis for (ii) providing those information in various application scenarios (Herwig et al. 2012). Having a wide spectrum of potential application scenarios as well as several ways of implementing a CRIS in the institutional environment, the aim of this contribution is to derive the most common design elements which could contribute to tighten the terminological understanding of what a CRIS is as well as serve as orientation in the process of fitting the research information system into the underlying environment.

3. Research Design

For the extraction of design elements, existing attemps to define a CRIS, qualitative research studies (Ribeiro et al. 2016; Sticht 2014) as well as current implementations are evaluated under consideration of a well accepted information systems framework. According to (Teubner 1999) information systems (IS) are social-technical systems which evolve through the three main factors the involved humans, the intended task and the used information technology. The actual shape of an information system is formed by reciprocal interdepencies of these components. For Instance, the intended task determines to a great extent the requirements for an appriotate usage of information technology. At the same time the definition of the task is significantly influenced by the included users as well as their organizational surroundings. Finally the information technology influences the shape of an information system insofar that the task completion can potentially get enhanced through IT on the one hand and on the other hand it brings restrictions for the concrete IS-implementation. Applying this framework to the context of research information systems a comprehensive specification and systematization can be developed. As a result a morphological box is developed which facilitates an extensive overview of the essential design elements including the broad spectrum of variants within those. This broad spectrum of variants within each dimension illustrates various application scenarios of a CRIS and the resulting implementation forms.

4. Results & Conclusion

Human and Organizational perspective

The human and organizational perspective defines the **environment** in which the CRIS will be integrated. Mainly such systems serve as university-wide integration platform for research information (Herwig et al. 2012). Systems with this purpose can be classified as CRIS for individual institutions. Another application scenario is the implementation as institutional CRIS in which researchers and their activities are being aggregated on the basis of several institutions. Possible dimensions for aggregation are regions or specific domains – e.g. one CRIS that merges all activities for one country or federal state (Johansson et al. 2012). Furthermore so called research portals are being established which consist information about research of specific discipline oriented communities(Becker et al. 2010). The involved **actors** of a CRIS depend at first heavily upon the underlying environment. Moreover the overall scope of tasks for which it should be used influences the group of actors to a great extent. Thus, a broad spectrum of possible actors is conceivable which ranges from the research themselves, the university administration to funders or the public media.

Task Perspective

In general, the **scope of application** of a CRIS can be summarized as IT-based support and execution for tasks in the field of research management. This can be further divided into the three main areas: (i) the dissemination of research information via various communication channels, (ii) the fullmilment of reporting obligations as well as (iii) the process integration for administrative tasks (Locker-Grütjen et al. 2012). For all main purposes the existence of reliable data is essential. As the data is located in various source systems or even in unstructured form, several **types of data collection** have to be taken into consideration. Similar to the type of data collection the **organizational responsibility and implementation of the data import** relies heavily on the circumstances and restrictions present within the institution. For instance, in an institutional CRIS the responsibility for data collection and import is most certainly allocated to researchers, the university administration and library staff (Sticht 2014). Finally the **contents of the CRIS** in terms of the data which will be processed and provided for the previously described use cases is highly task-depend. The information needs the institution has to fulfill can be seen in this phase as suitable first reference object. Applied to the german research environment the so called *Kerndatensatz Forschung* is a national specification which is supposed to foster the establishment of common standard (Wissenschaftsrat 2016). Furthermore on the European level with CERIF a reference data model exists which is under continuous development (Jörg et al. 2012).

IT Perspective

In contrast to the most common understanding of a CRIS as a single software platform which covers all functionalities in this environment, several different **IT-architecture concepts** are conveivable. Besides this monolithic approach, the research management can be implemented in two or more software systems in a modular manner. This setting is particularly suitable if the institution already has well-developed information systems within the university administration and the library. Here the CRIS is a conglomerate of different application systems connect through an integration platform. Another aspect of the IT-perspective which is closely linked with the general architecture is the method of **data storage.**

Dimension	Value					
Environment	Institutional	Community-related				
Kind of Organisation	Single Institution	Group of Institutions				
Actors	Researcher	Management	Commitees	Academic planning	Library	
	International Office	Public Relations	Funder	Companies	Media & Press	
Contents	Persons	Organizations	Publications	Projects	Awards	Patents	Research intstrumentation
	Doctoral Studies	Habilitations	Cooperations	Memberships	Classifications	
Scope of Application	Research dissemination	Research Reporting	Process integration			
Dissemination of Research Information	Research Portal	Dynamic Provisioning for Personal Webpages				
Reporting	Dashboards	Ad-hoc Analyses	Advanced Analyses			
Process Integration	No Process Integration	Organizational Process Integration	Technical Process Integration			
Type of Data Collection	Manual Data Collection	Automated Import from Source System	User-triggered Import from Source System			
Responsiblities of Data Collection	Centralised Acquisition	Decentralised Acquisition	Decentralised Acquisition with centralised Validation	Centralised Acquisition decentralised enrichment		
Regular Cycle of Data Collection	Continuous	On Occasion				
Type of Data Storage	Isolated Data Storage	Central Data Storage	Dynamic Linking			
IT-Architecture Concepts	Monolithic Architecture	Modular Architecture				

Figure 1: Design Elements of Research Information Systems

Based on existing qualitative studies, existing definitions and practical knowledge gathered during the operation of a CRIS, the main characteristics of such systems were derived (cf. figure 1). The resulting morphological box provides a comprehensive systematization which can be used for further stages of development like the derivation of detailed system categories.

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7. Hint

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GIVING LEADERS AND MANAGEMENT EASIER ACCESS TO STUDENT DATA

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Keywords: Student data, analysis, visualization, data warehouse, BI, Tableau

All Norwegian higher education institutions (HEIs) use common, national information systems to support HEIs' most central activities: research and studies. The three main information systems are:

- FS – *Felles studentsystem* – national student information system,
- SO – *Samordna opptak* – national admission system
- CRISTIN – *Current research information system in Norway*

The above mentioned systems are developed at CERES - National Center for Systems and Services for Research and Studies. These common information systems contain considerable amount of data, but it is not always easy for leaders and management to get the data they need in a form which is suitable for their needs. In this paper we will present the national project and the work that was done to make the data in the Norwegian student information system FS more accessible to both administrative and academic leaders and management.

The first step in the process focused on pinpointing what area of data that was most relevant to start with. Previous attempts at developing analytical reports suffered in some ways because of the scope for the report sheets that was defined too broad. The attempt to make the "ultimate" report that contained everything in one place was abandoned. In order to take a fresh look at the task and at the same time ensure the necessary involvement of the HEIs, a national committee was established. The committee's recommendation was to focus on development of the following analytical reports: reports presenting number of students, the number of degrees and how many students that drop out during the course of their studies at the Norwegian HEIs. This includes also data about the period of time the students used to get their degree.

After the committee's conclusion was submitted, it became evident that the software that was used for developing and implementing the reports was not suited for the job. The committee stressed the importance of more emphasis on visualization, making the system one had at hand not well suited for the job. The HE-sector was in need of a new system for developing the analytical reports for retrieving and presenting the data from the Norwegian common information systems.

After a time-consuming and challenging tender process, the business intelligence software Tableau was chosen. The process of development and implementing the reports was coordinated and executed by the Section for data warehouse at CERES. The software and the analytical reports were tested by just a few users from each University and University College in Norway. The first users were all advanced users and experts of FS, the student information system, since a good knowledge of the data in the reports was one of the main prerequisites of successful test of the reports. The testers tested the quality of the data in the analytical reports as well as the design of the reports in order to ensure that the criteria in the project description designed by the first of the national committees were matched. The reports were made available for the leadership and management at the HEIs.

The HEIs are now able to give easy access to data that previously was only accessible to a few. The data is also presented in a more clear manner with emphasis on graphs and visualization. The reports help the institutions getting comprehensive information about their students and ensure a proper decision support. The HEIs can now easily take a look at the data about the number of students, degrees and drop outs at the different levels of detail in their organization. The can choose between a broad picture at the institutional level or the detailed look at some specific bachelor programs, and looking at factors such as age, gender and grade point average from high school. The development of more reports continues and is conducted in close dialogue and based on the needs of the institutions. Examples of reports developed during the project will be given at the presentation.

Ragnar Pettersen has a Master in Mathematics from them University of Oslo. He has previously been working at the Department of Mathematics at the University of Oslo with student and research administration. He is currently working at CERES - National Center for Systems and Services for Research and Studies at the group for Data Warehouse as a Senior Engineer. He is in charge of developing the reports in Tableau for student data.

Digital Transformation and the Changing Role of Student Administrators: A Case Study

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Keywords
Digital transformation, student administration, student information system, workplace health, change management

ABSTRACT

Information and communication technology is at the core of administrative work and it has a significant influence on work and on the work environment. This paper presents a study designed at understanding the digital transformation of student administration at a large university. Through quantitative and qualitative data, different aspects of the digital workplace are highlighted. The study is part of the preparation for a new student information system that will radically change the work processes of student administrators. The current state of the transformation is described with help of the demand-control-support theory. Results indicate that motivational factors score less well than hygiene factors. The paper concludes by discussing possible strategies for increased resilience during the transition to a new student information system.

INTRODUCTION

Rapidly increasing use of computer systems in all sectors of work life has had significant influences on efficiency and flexibility in organisations, as well as on the nature of individual employees' work – often positive, but sometimes also negative. Unfortunately, the increased use of computers in work life has had undesirable side effects in terms of health. At the same time as computers have entered the workplace, occupational health problems have reached an alarming level. As computers are increasingly used in working life, the number of health concerns and reports of negative effects on users' health have steadily increased. In the public sector, sick-rates are consistently high - over 10% in some organisations and for certain groups. This is part of a general trend in Sweden, where sick-rates and the costs of sick pay and rehabilitation have increased dramatically since the early 1990s. The problems are caused by multiple interrelated factors including job pressure, poor workplace design, repetitive work and poor work posture, and poor social support. Inadequate IT systems with poor *usability* are significant contributors, despite several years of research efforts, and efforts from unions to increase the attention paid to these issues.

In an increasingly competitive higher education environment, Student Affairs is of strategic importance to universities (Porterfield & Whitt, 2016). Student Affairs include a number of activities and many of them are focused on face-to-face contact with students, such as career advice or counselling. Student Affairs also rely on ICT (Cabellon & Payne-Kirchmeier, 2016). Here, the student information systems (SIS) is important. A SIS is a complex system in itself but it is also a critical part of every university's information architecture. At the same time there is a general transformation of office work, caused by a complex interplay between new technology, globalisation and demography. Information and communication technology (ICT) is becoming a defining factor of the workplace. Well functioning ICT is necessary in order to provide an attractive workplace.

This paper presents a study related to student administrative work at Uppsala University, and the digital work environment of student administrators. We will first give some background to the study. Then we will shortly present the theoretical background as well as the methods used. Next, we will then point to some of the results from the study of the digital work environment of student administrators, and conclude with a discussion of some possible implications for managers.

BACKGROUND

Sweden is in the process of replacing its national student information system Ladok (see Brorsson & Ringeborn,2008 for an overview of the current system). The project is one of the larger public ICT developments in Sweden, with a budget around 50 million Euro. The implementation began in late 2016 and will continue throughout 2018. Apart from the completely new code base, one major aspect of the new Ladok is an increasing amount of self-service, to be performed by teachers and students, radically changing the current work processes in student administration. The new Ladok will be used by all students in Swedish higher education as well as academic and administrative staff–totalling around 400 000 students and 50 000 staff (2015). The system is very much the backbone of Swedish higher education. On a national level the system is integrated with systems for student enrolment and handling financial aid to students. On the university level it is is increasingly becoming a critical part of each university's ICT infrastructure. Here, the usage spans from authentication to integration with various learning management systems (LMS).

The student information system is managed by a national consortium, which owns the project that develops the new system. The development project is also responsible for the overall national implementation plan. Yet, given the scope of the project a significant part of the implementation rests on each university and each department within the respective universities. This includes the more formal aspects such as validating the migration of data as well as system integrations on the university level. Finally, it includes the redesign of administrative work processes and the development of training programs and new support structures at the respective universities.

Uppsala University is one of the largest universities in Sweden with approximately 6500 academic and administrative staff and around 35000 students, almost all of whom will be affected by the new Ladok system. At Uppsala University there has been a large project preparing for the implementation (scheduled for 2018). The university has also been planning to implement a new LMS and rebuild the student portal. Thus, the university will experience massive changes in the ICT infrastructure for both teaching and student administration. Not surprisingly, it has been high on the university's agenda to achieve a successful implementation.

In order to support the local implementation project an auxiliary project was formed with our research group. We are working in the field of human-computer interaction, with experience of other large-scale implementations in public organisations. The collaboration was based on the concept of action research (Hayes, 2011). This, in the tradition our research group adheres to, requires involvement that might be foreign to other research traditions. In action research there is thus a double aim of doing research and supporting change processes (McKay and Marshall, 2001).

The benefit of this approach for research is that it often provides access to on-going projects and the complexities of systems development in the quickly changing field of ICT.

The auxiliary project included a number of activities such as coaching the project team on both individual and group level. The strategically most important effort were a number of vision seminars conducted in 2014, aiming at creating a unified vision for the future student administrative work (Lind et al, 2016). The idea behind this is that by first creating the vision–with people actually doing the work–it becomes possible to try to adapt the system to the business rather than the other way around. The vision seminars resulted in a vision that is now guiding the local implementation project and the process itself has been an important effort in getting acceptance for the inevitable change that is coming. Importantly, the seminars also included the perspective of the students themselves.

This paper presents another part of the collaboration in the form of a study of the digital transformation of student administration, as an input to the implementation project. The aim was to allow a follow up and possible continuously monitoring of the effects of the new SIS on the digital work environment of student administrators. As a consequence, it hints at some areas that might be of strategic importance for an organisation wishing to improve organizational resilience during major ICT implementations. In the next section we present the theoretical background and methods used for the study.

THEORY AND METHOD

The overall idea for this study has been to capture the relation between ICT and well being at work. The theoretical framework for this paper is that of healthy work, as developed by Karasek & Theorell (1999). This theory is an extension of Karasek's *demand-control* theory, with the addition of *support* as a third dimension. In short, the demand-control-support theory states that healthy work can be understood as a combination of three dimensions: The demands placed on the worker, the control the worker has over his or her work and the support that the worker gets in the workplace. If control and support is perceived as high, the worker can tackle quite a high demand as well. The lower the demands, the less critical are support and control. If demand is high, but support and control remain low there is an increasing risk of job strain, burnout and other negative health impacts. Thus, looking for indicators of these dimensions is important when studying the work situation of a given group.

In our interpretations of the results we also make use of the Herzberg's motivation-hygiene theory. This theory states that there are certain factors at work that cause job satisfaction (motivation factors), while a separate set of factors cause dissatisfaction (hygene factors). Examples of motivation factors are responsibility, recognition, opportunity to do something meaningful, involvement in decision making. Examples of hygiene factors are job security, salary, work conditions and vacations.

For this study, empirical data was collected in the following ways. Data from the university's HR-system as well as SIS was used to build a quantitative understanding of the structure of the university's student administration. Six semi-structured interviews of about an hour each were conducted with student administrators. A survey was distributed to the university's 322 student administrators (defined as users with high access rights in the SIS). The survey was available online and unique links were distributed to via e-mail, it was open late November-early December 2016 with a response rate of 54%. The results have been presented at a seminar with some 70 representatives and in connection with this additional feedback were collected.

Student administrators form a heterogeneous group. About half of the respondents have titles more or less equal to that of “student administrator”. But there were some forty different titles in the group, hinting at rather diverse tasks above and beyond those of student administration. Some work full time with student administration while others do this part time, in combination with other administrative tasks including HR or finance. Gender balance is uneven, as the large majority are female.

There are also important organisational differences. The departments within the university belong to one of three divisions: science, medicine and humanities. These divisions have their own administrative regulations. Furthermore, the size of the departments varies from quite small to very large and with increasing size, administrative resources increase both qualitatively (specialization) and quantitatively (colleagues). Finally, student administration is also influenced by how the teaching is predominantly organised, either in shorter courses or in long study programs.

The interviews included questions on background and work, with a focus on demand, control and support. The respondents were found through a combination of recommendations and announcements in relevant channels. The interviews also provided a two general hypothesis that we hoped to try through the survey. In short these were the mediating effects of experience and professional networks on the experience of the digital work tools.

The survey was based on three established survey tools: the System Usability Scale (SUS) (Brooke, 2013), as well as tools from TCO (UsersAwards) and Prevent (IT-stress Survey). The first is an internationally well known tool while the two latter are publically available tools that have high visibility in Sweden. Another paper discusses these aspects on a more detailed level (Nauwerck et. al. forthcoming). Here we will focus on the main results, which are presented in the next section, combining findings from the data collection, the interviews as well as the survey.

RESULTS

The most important result from the study relate to the changing role of student administrators, as an effect of an on-going digital transformation. ICT has been an important part of student administration for a long time now. Yet, it was also clear that the scale of this transformation was not understood by the rest of the organisation, and that the image of a student administrator is still associated with paper shuffling and simple routine work. Student administrators experience that their colleagues in general and managers in particular do not understand what they do, especially in relation to ICT. From the interviews, for example, it was evident that learning how to work as a student administrator takes at least two years of experience since some work procedures are yearly. Evidence from job adverts indicate that this understanding is not well articulated, beyond “familiarity with the office suite and previous experience of the university’s ICT systems”.

To fulfil their work, the student administrators rely on a large number of ICT-systems (normally around 10-15), the SIS being just one of them, albeit the most important. Many work processes rely on more than one system and there is often limited integration between the systems. When one system is used, for example, it can be necessary to work on a separate spread sheet to parse data in ways that the system cannot do.

Overall the ICT systems do support work, and many student administrators testify to their value. Some student administrators who have some years of experience also reflect on the progress and improvements made in many ICT systems. In fact more than one states that the system portfolio right now is in a mature and productive state. This can be said to be reflected by the overall System Usability Scale (SUS) score results from the survey, which was 63/100 (68/100 is suggested to be a normal SUS score). As the SUS score is just an indication, we will now drill down a bit further and look at the dimensions of demand, control and support.

Demand, Control and Support

In the following we use the dimensions of demand, control and support from Karasek and Theorell (1999) and concepts from Herzberg's motivation-hygiene theory as frameworks to structure the results. In total there were more than 80 questions in the survey, table 1 gives an indication of some of the major trends related to demand, control and support:

Dimension	Statement	Positive responses
SUPPORT	Users participate actively when new ICT is introduced	54 %
	I have the knowledge I need to manage my ICT	79 %
	The support I get is sufficient	95 %
CONTROL	My ICT systems do not overly constrain my work	56 %
	My ICT systems make my work more predictable	79 %
	I can manage my ICT systems	95 %
DEMAND	I can respond promptly to requests arising from the systems	36 %
	The amount of information I receive is acceptable	65 %
	I can respond to teachers and students	95 %

Table 1. Nine questions relating to the three dimensions. Answers have been grouped together as percentage of positive responses. The original questions were in Swedish.

The most important observation to be made is that for each dimension the result varies. Our interpretation is that the higher values are for what can be called hygiene factors for each dimension. Conversely, what can be defined as motivational factors get lower scores. Next, we will elaborate on the three dimensions in more detail. It should be noted that the framework mainly serves a cognitive purpose here, in reality there is much more overlap and interaction between various aspects.

Demand

The student administrators are committed to service, supporting both students and teachers. Demand for quick responses is high from both groups. Student administration is often dependent on formal deadlines, often related to formal decisions (for course registration etc.) which puts much stress on the administrators. A large majority of the student administration work is oriented towards these deadlines. One team of administrators had even produced a chart to explain the sheer number of deadlines to their colleagues. Even though there are deadlines throughout the semester there is also a cyclic pattern with extra high demand on the administrators in certain periods, such as the start of each semester.

Control

Control relates to the overall decision latitude–or autonomy–the administrators feel they have over their work–and to what extent ICT constrains this.

The survey covers various aspects of control, including autonomy, computer competence and predictability. There is some disagreement regarding the level of autonomy the systems support. Nevertheless, there is an overall consensus among the respondents that they can manage their ICT tools (with everyday tools scoring higher than those less frequently used). Predictability. finally, also follows a normal distribution but with slightly higher values at the negative end of the scale, compared to the positive. Contributing positively to control is the sense that student administrators have a rather unique position working closely with teachers and students but also the central administration. Experience is also important for a sense of control. The relatively low status of student administration (compared to research) contributes negatively and can also be a factor influencing social support.

Support

When it comes to the dimension of support, there are a number of sources. The interview respondents rate the support from the university's central SIS team very high. The support is described as very dedicated and competent. Management support is discussed in the interviews though not in the survey. All departments have a head of the department but the interviews indicate that the student administrative work is rather invisible and not always seen as important. This can somewhat be countered at larger departments where the administrators form teams, sometimes even with some kind of team leader or chief administrator. This is seldom an option in small departments, though.

Some student administrators participate in formal and/or informal professional networks. These are regarded as very important as they are a source of best practices, inspiration and contacts with colleagues in similar roles (the ones at the same department often have different roles). Finally, in some cases the support from partners/spouses is mentioned as important, especially when the partner has some kind of ICT background, and can provide a second opinion to the internal support organisation of the university.

While most projects and systems have some kind of user groups the results are somewhat mixed when it comes to participation in development projects.

DISCUSSION

In summary, the results present a complex image of the current state of student administration. What is currently functioning well are what can be called hygiene factors (functionality, support etc.) whereas there is room for improvement when it comes to motivational factors (such as being seen, learning, collaborating etc.). Interestingly enough, this may well change as an effect of the large-scale implementations that will occur over the next few years. The possible reason for this is that a change processes will usually follow some kind of J-curve, that is there will be a loss of productivity before processes are running smoothly again, as in Figure 1 below.

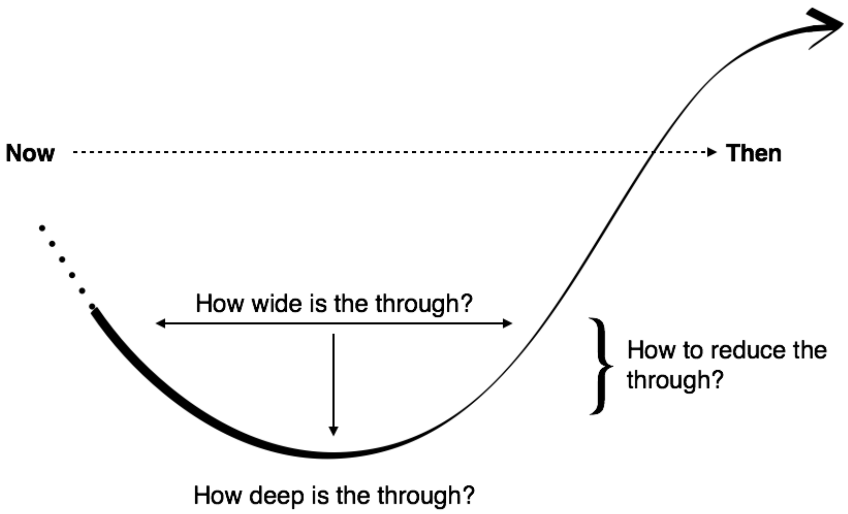

Figure 1. A generic change curve. Rather than a linear progression there will usually be a loss of productivity followed by a recovery period. How wide and deep the through will be varies and one challenge during change is to reduce the through. The idea of the change curve originates in Kübler-Ross' (1970) theory of grief.

It is quite possible that during the implementation the hygiene factors will come under pressure (bugs, less support resources etc.). This might to some extent be compensated if motivational factors are promoted. A well-managed change might result in just that, a sense of being seen and being an active part in the transformation.

IMPLICATIONS FOR MANAGERS

We conclude with a few action items for managers who wish to support the digital transformation of student administration. While generalized, they should of course be adapted to the local context on the basis of local studies. Indeed, this should be a prerequisite for ICT enabled change: always maintain a strong user perspective through both participation and metrics.

Acknowledge the Changing Role of Student Administrators

The most important implication for managers is to acknowledge the changing role of the student administrators. As the digital transformation is well under way this is of general importance, but it is of course critical during large scale changes such as when implementing a new SIS. For managers outside ICT this understanding would also include improving their general digital literacy (Kolomitz & Cabellon, 2016).

Understand the Value of Work Experience

Work experience is important in study administrative work, and given the complexity of today's student administration it takes time to build this experience. The cyclic nature of student administration means that some tasks will be new the first year and indeed it seems to take more than a couple of years to even become confident with the basic procedures. While new staff will in some ways be more computer savvy than the generation that is retiring, they will not be fully productive their first year. This will probably also have impacts on satisfaction rates during changes, as experience seem to counter some of the negative perceptions of the current ICT systems. Possible strategies here include planned recruitments, allowing for more informal and formal training.

Promote Networks and Structures

Informal and formal professional networks as well as organisational structures are important for overall resilience. Networks provide more of an ad hoc support. For day-to-day working, a team sharing the work is key. Many departments already have administrative teams but some do not and this might prove to be a risk. As this mainly is the case within smaller departments one solution could be cross-departmental collaborations, on a more formal and continuous level than what can be achieved through networks alone. Related to the previous point it is also important to include the less experienced in networks, as well as finding ways to include those who are outside of the networks.

Support the Support

The student administrators clearly view central support as important and in this case the support is understood as very good as well. Yet, there are indications that a high level of support can also be seen as a luxury well above good enough support and thus subject to cost cutting. As the ratio between support and administrators is 3:100 (counting high) it is not the most costly part of the overall student administration. On the contrary, there is an obvious risk that reduced support levels might propagate through the system, which will eventually be noticeable by the far larger numbers of teachers and students using the future SIS. Still, there are more strategies to strengthen the support organisation than just expanding the central administration. Alternate strategies might include strengthening collaboration between various levels, promoting super users etc.

FUTURE WORK

The study presented in this paper has given interesting insights, and a number of new areas to study have emerged. One area would be to look at the wider job situation and the work environment including measures relating to job satisfaction and job strain. Another would be to investigate the views on student administration of managers, teachers and students (to some extent this was included in the vision seminars though). Finally, the relation between various organisational structures, professional networks and student administrators would be interesting to examine more closely.

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Gerolf Nauwerck is a PhD student in Human-Computer Interaction at Uppsala University. He has been working as an IT-strategist and business analyst but is now focusing on ICT related change management and health. In particular he is studying what in Sweden is called “the digital work environment”. He can be reached via www.linkedin.com/in/gerolf/

Supporting Student Mobility — Expected and unexpected results from the EMREX Field Trial

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Keywords
Learning mobility, student information systems, digital result exchange, European policy experimentation, automatic recognition

1. ABSTRACT

The EMREX network, co-funded by Erasmus+, addresses the EU 2020 target that 20% of higher education students should be mobile during their studies. EMREX focuses on the electronic exchange of student achievement records between higher education institutions. EMREX together with e.g. Erasmus Without Paper, FAIR, OLA, and other similar initiatives is part of a wider set of activities on student mobility by EU. Academic recognition in higher education is seen as a challenge in learner mobility and also as a potential area for the improvement of a more efficient education system in general.

In 2016-2017 the EMREX project ran a Field Trial aiming at testing new ways to make the administration of student mobility easier between Finland, Norway, Sweden, Denmark and Italy. Over 100 students from 30+ HEIs in these countries have already logged into their student portals at their home universities and collected their study achievements electronically from the host universities, without the need to send paper copies.

This session aims at presenting the findings from the EMREX Field Trial; what did the students think of EMREX, how can EMREX help the university administration, and what expected and unexpected results came out of the field trial?

2. THE EMREX FIELD TRIAL

The EMREX Field Trial has been in operation for one year and to test the tool even further the project decided to extend the trial period until the middle of 2017. The decision makes it possible to also include students who come home from their exchange period during spring semester 2017. Norway, Finland, and Sweden have been in production since early 2016, with Italy joining late 2016 and Denmark early 2017. Over 100 students have already used EMREX, with more to come in 2017, from 30+ HEIs. In Norway and Sweden all HEIs are involved, in Finland all HEIs for incoming students and 4 for outgoing students. In Denmark 4 universities deliver results to EMREX to start with and in Italy Siena and Verona are the first to join EMREX.

Table 1 contains the number of students up until January 2017.

Country	HEIs (imported or delivered results)	Number of students that imported results	Short surveys
Finland	9	ca 30	26
Italy	1	3	1
Norway	9	>60	32
Sweden	4	5 (+40 internal)	10

Table 1. Number of students using EMREX up until January 2017.

In parallel to the Field Trial Poland has developed the tool for internal national mobility and is already connected to EMREX. DUO in the Netherlads is also developing EMREX, with many more partners knocking on the door.

A short survey included directly in the EMREX-tool asks about the student's experience of the transfer (table 1). The feedback in these surveys, in addition to evaluation purposes, has also provided good help for further development during the Field Trial.

3. THE EMREX SOLUTION AND STANDARDS

EMREX is a decentralised network consisting of several components. For consumers of the result data the network is open and the student herself is in control of the data exchange. The decentralised model also makes it easier to add new providers of student result data to the network.

Each SIS or institution that wishes to retrieve results from the EMREX network can connect using a standard Student Mobility plug-in (SMP). This then becomes an EMREX client, and enables the student to retrieve her result data from the EMREX network.

Each country that seeks to provide results to the EMREX network must implement one or more National Contact Points (NCP). The NCP provides the student with a secure login, and enables her to select the results she wants to share with the EMREX client.

The EMREX network uses the standard-based ELMO format to exchange the results. The only common component for the EMREX network is a registry (EMREG) of NCPs.

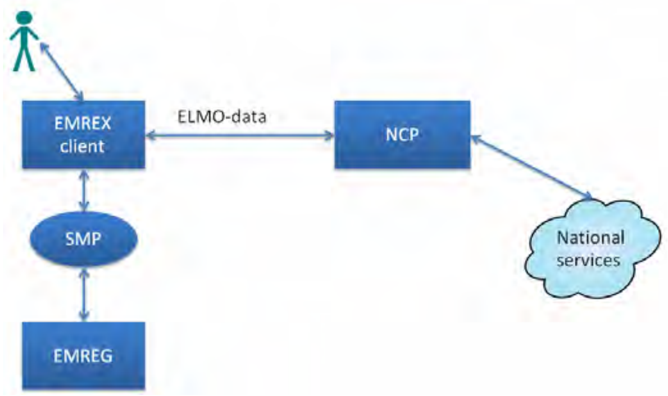


Figure 1. Components of EMREX

The process is initiated by the student, by logging into the EMREX-client (see Figure 1). It contacts the EMREG registry to check which NCPs are available. The student chooses the country and HEI from where the result data are to be retrieved, and the data is verified by the NCP. An electronic transfer of student achievements via the NCP and SMP is performed as soon as the student has approved the list of results to be transferred.

The EMREX solution will be demonstrated live in the session.

EMREX is based on open source code and freely available to all. The solution is available for all HEIs in Europe from 2017. New countries can join the EMREX network by creating their own EMREX clients and contribute to the network by providing their own NCPs.

4. EXPECTED AND UNEXPECTED FINDINGS FROM THE FIELD TRIAL

The EMREX Field Trial was conducted with 100+ students from 30+ HEIs in 2016 and will continue until summer of 2017. From a technical point of view EMREX uses well proven technology and it was not surprising that the network is stable and works well across countries with different local systems. Students found EMREX to be fast and easy to use, and in many cases the students were surprised that such a system for electronic transfer did not yet exist. In the google-era students are used to doing everything online. As part of the Field Trial a survey was conducted with the students. For nearly every statement (see Figure 2 below), the share of the participants who have favourable views on EMREX is higher than 70%. Out of all statements' rating the one concerning the ability to import all data was the most correlated with the overall satisfaction with EMREX.

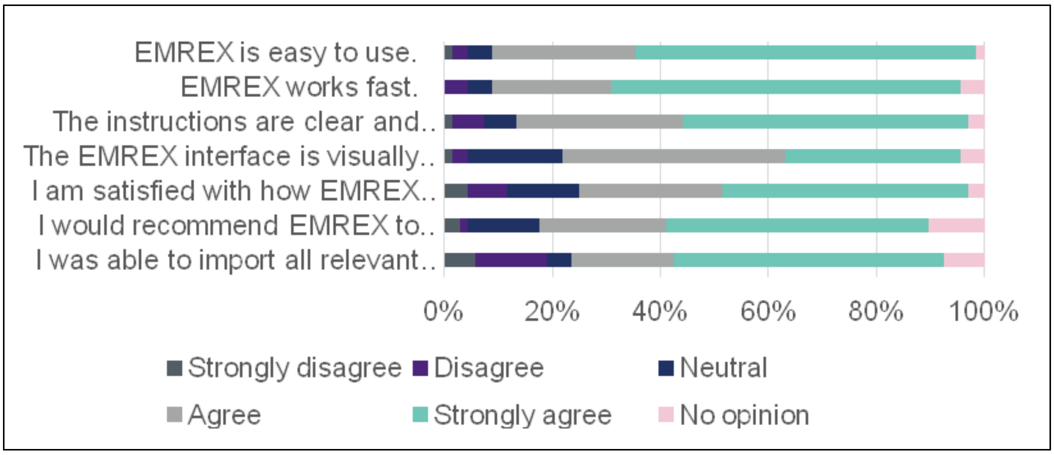


Figure 2. Evaluation of user experience (frequencies)

From the HEI SIS perspective the Field Trial revealed a couple of issues that need to be addressed in the future. Although HEIs talk about lifelong learning, in some countries they are very quick at deleting student accounts as soon as the student leaves. Also, despite the Bologna process and ECTS guidelines, it was evident that not all HEIs have yet changed their own processes and a key area, when moving towards automatic recognition, will be to define the minimum content to be shared and common standards for data formats. What data should be included? How should a European automatic recognition process work? EMREX proved that this is not a technical issue, but rather needs a common policy. Perhaps as part of Erasmus 2020 and onwards.

The Field Trial was aimed at exchange students, but perhaps a little surprisingly EMREX soon generated a great interest among admission officers and for internal mobility. Also, despite EMREX being a Field Trial and not aiming at expanding yet, Poland and the Netherlands already decided to join the network. The need for digitalized student records is evident.

A common comment from the Field Trial was that EMREX is great, followed by a question, if also course descriptions and grade conversions could be included. A PDF version of the achievement records was included as a temporary copy for the student personal use, but soon the PDFs were being used in the recognition process. There seem to be a demand for digitally signed PDFs.

A known issue beforehand was how to identify the student and how to provide privacy for the student' data. This, however, was not seen as an issue by the students. They were happy to download their results, check them and share them with the home HEI.

5. FUTURE STEPS FOR EMREX

The successful Field Trial has shown a need for EMREX. The current partners are all committed to continue using and enhancing EMREX to support student mobility and as EMREX in most cases is already integrated into the existing SIS system it will automatically be continued to be supported. The partners have also decided to apply for EU funding to spread EMREX to more EU countries and to prototype innovative ways of using achievement records.

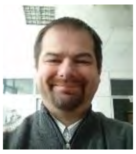
During the Field Trial it was discovered that electronic achievement records would be a valuable addition to admission processes and in credential evaluation and this work is already ongoing. Course descriptions, course catalogues, grade conversions, and support for diploma supplements also all offer interesting possibilities that could be further explored. Expanding EMREX to countries outside EU and to expand cooperation with projects like Erasmus Without Paper is also on the future roadmap.

EMREX has proven itself to be a valuable building block for student mobility. The technology is there and the next step is to extend the EMREX network and at the same time start working on aligning the processes and data standards to pave the way for smoother student mobility and automatic recognition.

6. BIOGRAPHIES

Mats Lindstedt has a Master of Science in Business Strategy and International Marketing and a Licentiate in Applied Mathematics from the Helsinki University of Technology. He has over 15 years of experience from the ICT industry including program management and R&D development. Since 2012 he works for CSC-IT Services for Science Ltd in Finland developing support for student services. Previously he was the project manager for Tiptop, developing web based support for university students' personal study plans. Currently he is the project manager for the EMREX project.

Anders Bøgebjerg Hansen holds a master's degree in political science from the University of Copenhagen. He has worked with different student information systems at two universities and has 15 years of experience coordinating systems development on the customer side within higher education in Denmark. He is a special adviser at the IT Department of the Ministry of Higher Education and Science (UFM-IT) where he works with contract and project management with relation to the student information system STADS and the application system DANS. These systems are used at all 8 universities and several institutions of architecture and art in Denmark. Anders Bøgebjerg Hansen has been the project manager of many large EU tenders and has for several years been involved in Nordic forums in the area of student information systems.



Stefano Russo has more than 15 years experience in developing nationwide software systems. He spent most of them at Kion, the company which is the leader in developing Students Information Systems for the Italian Universities, where he works as part of the group that manages the mobility module for the student information system "ESSE3" used by over 60 universities in Italy.

Geir Vangen has more than 20 years' experience in developing nationwide systems within higher education in Norway. At CERES, he works as manager of the Department of development. CERES develops systems for student information (FS), research information (CRIStin), national admission (SO) and data warehouse, in addition to a number of services like the Diploma Registry. He participates in national and international standardisation work, and has been a member of the groups developing the MLO and ELM-standards. He has been member of national committees appointed by the Ministry of Education and Research, and has led projects on behalf of the Ministry. He leads work packages in EMREX and EWP projects. Geir Vangen graduated from University of Oslo, Institute of Informatics in 1989.

Janina Mincer-Daszkiewicz graduated in computer science in the University of Warsaw, Poland, and obtained a Ph.D. degree in math from the same university. She is an associate professor in Computer Science at the Faculty of Mathematics, Informatics and Mechanics at the University of Warsaw specializing in operating systems, distributed systems, performance evaluation and software engineering. Since 1999, she leads a project for the development of a student management information system USOS, which is used in 53 Polish Higher Education Institutions, gathered in the MUCI consortium. Janina takes active part in many nation-wide projects in Poland. She has been involved in Egracons, EMREX and Erasmus Without Paper European projects.

Pamela Engström obtained a Degree of Master of Science in Biology from Mälardalen University College in 2007. After graduation she worked as a municipality biologist, where her focuses included production and distribution of scientific information to the public. Since 2009 she works at the University of Gothenburg as a degree officer and project leader at the Section of Degrees with educational and degree related issues and analysis and evaluation. In the EMREX project she is the representative of the national consortium Ladok, as the project leader of the field trial work package. The consortium owns the Ladok system, which is the higher education industry standard in Sweden; the system is used at 37 of the universities and university colleges.

EMREX and EWP offering complementary digital services in the higher education area

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Keywords
Erasmus+, student mobility, Student Information System, digital mobility, student data portability, grade conversion, learning agreement, transcript of records, certificate and diploma supplement, digital signatures

1. ABSTRACT

EMREX (*Field trial on the impact of enabling easy mobility on recognition of external studies*) [1, 3] and **EWP** (*Erasmus Without Paper*) [2, 4] are two European projects funded by the *Erasmus+ Programme, Key Action 3*, running almost in parallel (2015-2017) and having some partners in common. EMREX is part of *Prospective Initiatives — European Policy Experimentations,* EWP part of *Prospective Initiatives — Forward Looking Cooperation Projects*.

For those looking at them from the outside their goals seem to be similar — the electronic exchange of student data among higher education institutions (HEIs). Both projects are very active in the *European Higher Education Area*, offering the digitalization of services which are now handled on paper, searching for solutions to problems of data availability, data privacy, and secure data transfer, looking for new partners (also from outside Europe), and planning to apply for extension in the new Erasmus+ call (March 2017).

If you are a higher education institution, interested in the digitalization of data exchange and the improvement of mobility processes, which of the two projects should you join? Is the effort involved doubled? Extending the IT services of your institution is a tempting but usually expensive decision to make. You should have good arguments to convince your superiors. Also, if you are to gain from digital data exchange, your partners in mobility should make the same decision. Should you join the pioneers or rather wait for the others to go first and eventually follow? Can you believe that the results of the projects will last longer than the end of 2017, at this moment the official end of Erasmus+ funding for both projects? Can you trust that what EMREX and EWP have to offer will make a real change in the digitalization of services in the higher education area in Europe and beyond?

In this paper we ask some provocative questions and offer guidelines for higher education institutions who look for realistic answers. In particular, the paper contains the thorough comparison of the aims, approaches and challenges of both projects and concludes with some practical advice on their dissemination and sustainability.

2. INTRODUCTION

The rapid development of digital technologies is changing the ways universities conduct research, provide teaching, and — last but not least — carry out their administrative tasks.

The internationalization of higher education results in increased mobility and cross-border cooperation — a target has been set by European higher education ministers to increase the number of students completing a period of study or training abroad to at least 20% by 2020. According **to** the 2011 EU Agenda for the modernization of Europe's higher education systems, sectoral priorities should involve "*improving the recognition of diplomas and credits or portability of grants through comparable and consistent use of ECTS and the Diploma Supplement, and linking qualifications to the European Qualifications Framework*". Students acquire education in the global education market and expect that the obtained diplomas and credits will be recognized everywhere.

EMREX and EWP are IT projects which incorporate digital technologies into services supporting internationalization and student mobility.

EWP and EMREX evolved from the early initiatives of the RS3G (*Rome Student Systems and Standards Group*) – an international group of higher education implementers focusing on data exchange standards (https://www.usos.edu.pl/Mobility/).

EMREX's main focus is on a student as the owner of the data and the main beneficiary of a smooth and easy recognition. EWP's focus is on the administrative officers in HEIs who every day bear the burden of making internationalization a reality in practice. Both projects implement services to exchange data electronically and deliver it on time where it is needed.

System integration may be achieved in different ways. There are well-developed technologies and tools supporting electronic data transfers. But up to now, there have not been many successful examples of integration in the higher education area. Both projects are pioneering in the integration – on a global scale – of **Student Information Systems** used in higher education to handle student data.

In the next chapter we describe in detail how EMREX and EWP integrate Student Information Systems of higher education institutions by building a common electronic platform offering digital services.

3. DIGITALIZATION OF SERVICES BY EMREX AND BY EWP

The EMREX project started on January 1st 2015 and lasts for three years. The project is coordinated by CSC Finland, there are 8 full partners. The EWP project started on November 1st 2015 and lasts for two years. The project is coordinated by Ghent University and there are 11 full partners and 11 associate partners (from all over Europe, and the US). There are four partners which take part in both projects.

Both projects aim at the digitalization of data exchange. Let us have a closer look at what that means exactly.

3.1. EMREX business scenarios

EMREX is based on the observation that a student is the owner of his study records. Data exchange is thus initiated by the student. The first implication of this student-centered approach is that the student has to use some web interface and also that the student should be recognized and authorized, i.e. have an active account in the system from which the data is taken. In the EMREX field trial, one finding was that in some countries it is, however, quite common that institutions invalidate student accounts shortly after they finish their studies. Accounts may last a couple of months after leaving, but are rarely valid indefinitely. The problem is even more significant in case of students coming to institutions for short term studies. A move towards more electronic services for mobile students will thus require a change in culture in the way HEIs regard the students and lifelong learning, or another way of identifying a person within the EU. Projects like **eID** (*electronic identity*) or **ESC** (*European Student Card*) may help to solve this but changing the culture can sometimes be a long process even if the technical solution is ready. The issue should be raised wherever and whenever possible to influence the changes.

The basic scenario tested in the EMREX field trial is the following. A student finishes his short term studies in a receiving institution and returns to a sending institution. The student wants to transfer achievements – logs into the local SIS (*Student Information System*) or student portal, chooses the receiving institution from the presented list (the local SIS obtains it from the **EMREX registry**, see Figure 1, which stores all the necessary binding information), is redirected to the system of the receiving institution, logs in again with the credentials from the receiving country. After approving data for export, the student is redirected back to the SIS of the sending institution.

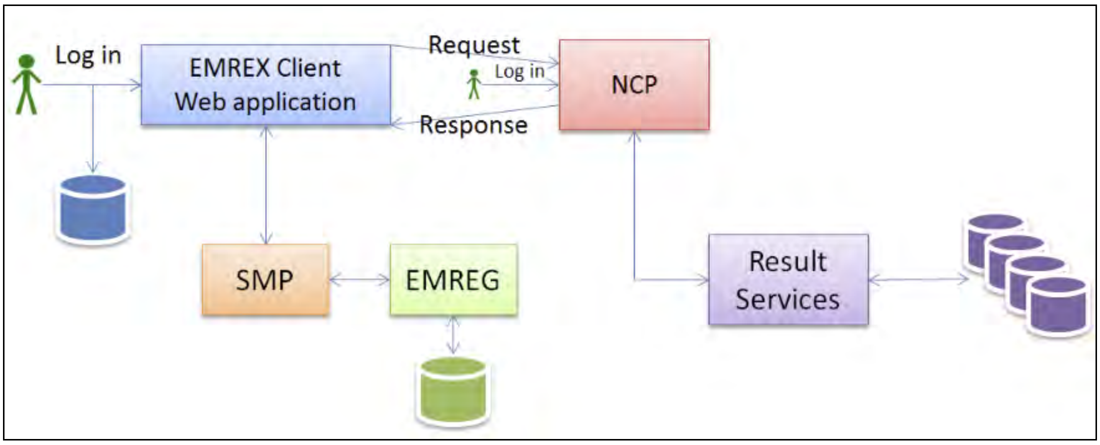

Figure 1 Main components of the EMREX network (from resources of the EMREX project)

There is one very important aspect of this scenario. Privacy is not an issue since it is the owner of the data — the student himself — who initiates the transfer and thus the receiving HEI or national data warehouse can freely give the data without any need for formal agreements between the HEIs or countries. The data is securely delivered to the local system/administration as it would be delivered on paper but is already available in an electronic form. It is the decision of the sending HEI based on the local recognition process, if the data needs to be further approved by the administration (staff of the student office) or be automatically incorporated into student records and recognized as official achievements.

Automatic recognition seems to be an attractive option but there are many open issues. Currently automatic recognition can most easily be used for national cross-studies, or in the case when courses from another institution are directly recognized during the process. A key issue is again the cultural background as in some HEIs it is part of the academic tradition that the final decision on recognition belongs to the local professors who base it on their subjective judgment. There is also an issue of grade conversion. It could be based on the *European Grade Conversion System* (**Egracons**) or on the course grade distributions calculated separately for each course and sent with the student achievements. Some HEIs offer such information in their transcript of records. Unless grade conversion is fully integrated with the data transfer, it cannot be the basis for automatic recognition, which in many cases makes it non-practical. This issue at the moment is beyond the scope of the EMREX data transfer scenario.

For the Erasmus exchanges, if the data transferred is a student's transcript of records, then in order to be fully recognized it should first be matched with the learning agreement which was signed before the short term mobility took place. This may be difficult if the courses from the receiving institution are not uniquely identified in the Student Information System of the sending institution. Sharing course catalogues between partners in mobility may help to solve this problem but needs more tightly coupled cooperation.

EMREX transfers data in an XML format with PDF included. XML gives access to structured data which may be further processed by the local system, whereas PDF provides a visual representation consistent with other documents issued by the same institution, to be displayed and printed. XML is signed with the system certificate.

It has not yet been decided if/how PDF should be signed. Also in this area there are differences in local regulations and requirements in different countries. What type of digital signature is legally valid? In Poland it should be a qualified certificate of a staff member who would otherwise sign a paper version of the document. Such signature cannot be obtained in real-time. A student might request such a document, but he would be required to wait until the qualified user signs it. Only then the data can be obtained. PDF signed with the qualified certificate is legally equivalent to the paper version signed by hand so it can replace it in any further process. The student can store it on a local computer and send it where needed. The digital signature is available for inspection in many common tools, like Acrobat Reader. To further enhance digital services for students also this area would benefit from common agreements.

Data is transferred through secure channels on its way from one place to the other so they cannot be tampered with. There is, however, one weak point from the security point of view. In our basic use case a student is supposed to log into the system from which the data is taken and also again into the system the data is transferred to. How can we be sure that in both cases this is the same student as the student will most likely have been given another local identity in the receiving country? Currently systems check some of the data, such as student's name, surname, date of birth. If the data do not match it is up to the local system to decide on the action to be carried out. In an extreme case the data can be rejected, on a less extreme level the local system can tag the data as needing further verification, e.g. a manual check. The local system should then present the data to a person authorized to approve them. In such a case full automation is not possible. The EU's eIDAS Regulation (Electronic Identification and Signature) and ESC might help in the future in this area.

EMREX uses the EMREX ELMO 1.1 data format (https://github.com/emrex-eu/elmo-schemas). ELMO has a hierarchical structure and focuses on learning outcomes which consist of other learning outcomes. Currently recognizable learning opportunities are degree programs, modules, courses, but others are also possible. That means that EMREX may also be used to transfer information about degree programs. That scenario is already carried out in Norway as part of the admission process. There is a plan to run a pilot with DUO in the Netherlands for sending data from a repository of diplomas stored by DUO for Dutch students to wherever those diplomas are needed to verify student credentials. In this scenario again a student should initiate the data transfer.

Diplomas and diploma supplements are also of interest when students apply for jobs. A student may transfer information about his achievements from the repository of diplomas, i.e. the home institution or some national repository, to the job portal.

A joint, multiple or double degree is a degree including courses where students have followed a joint program and done their studies in two or more institutions in two or more countries. A joint degree means the participating institutions divide the courses needed for a degree. In the case of double degree or dual degree the institutions provide an opportunity to get two degrees in a streamlined way so that the time needed is less than getting the degrees separately. In all these cases the degree certificate or diploma supplement must present all courses that are included in the degree and help to fulfill the degree requirements. As of today many countries manage this process manually and signed originals are often a must as a basis for transfer. The process for the student to receive the transcript and to deliver it to the home institution and the process for the administrator to register the results in the local study documentation system are both time consuming.

EMREX may facilitate the administrative processes around issuing joint, multiple or double degrees.

On a student's demand EMREX can transfer all data available from the original transcript digitally to the home institution where it can be downloaded directly into a certificate or diploma supplement. The secure verification process means that no original papers will be of use and the administration can be fast and minimized.

Last but not least, data on student achievements are most probably taken from the system where student records are stored — being it a Student Information System of the institution(s) where the student carried out part of his studies (like in Norway, Denmark or Sweden) or some aggregated data repository which stores data obtained from various higher education institutions (like in Finland). On the one hand having a national repository should help to implement data delivery, on the other such repositories may lack some required data. For example in Finland the VIRTA national database contains the achievement records but at the moment e.g. lacks data on course enrollment, course description, or diplomas, which could be needed for some other mobility processes. Also, a student needs to have the national identification number (Hetu) to have his data transferred to VIRTA (which is not always available for foreign students). There is also a question of data availability. Data is first stored in the SIS then transferred to the central repository. Depending on the process, that may have an impact on timely data availability.

To sum up, EMREX may be in use whenever students decide to transfer information about their learning outcomes from the institution where these have been achieved as long as they are stored in a digital form. They can then be sent to the institution or another system/process where they are needed — also in a digital form — to validate student credentials. Whatever is later done with the data in a target system is not part of EMREX. In particular the administration is not directly involved in the EMREX-supported scenarios.

3.2. EWP business scenarios

EWP is mainly focused on supporting the HEI administration for student exchanges (through Erasmus or in another way). Data handled by the administration is gathered in the database of the Student Information System. The mobility data is either stored in the same system in the so-called mobility module or in the stand-alone mobility application (which may involve commercial software). The main stakeholders of the basic EWP scenario developed for the pilot, are staff members of the International Relations Offices responsible for the Erasmus+ program and/or other exchange opportunities. The scenario starts with signing interinstitutional agreements between institutions of higher education. The agreements specify the number of mobilities (for students, lecturers, researchers), the types of mobilities (study, internship, lectures, research) and much more. These data need to be stored in both institutions to be used to control the mobility process.

Institutions exchange fact sheets which contain basic information on the institution or a specific organizational unit for people coming from abroad (or just considering arrival), e.g. e-mail addresses and internet contacts, language requirements, ECTS requirements, grading system, support related to visa and insurance. Data embedded in fact sheets can have a structured form which enables further electronic processing or be combined in one PDF document which can be posted on the partner institution's web page without further processing.

Every semester students are nominated for an outgoing mobility period. Nominations are prepared by the sending institution but need approval from the side of the receiving institution. In particular the number of nominees cannot exceed the value agreed in the interinstitutional agreement. The receiving institution can either accept or reject the list of nominations.

The nominated students should negotiate a study program with the receiving and sending mobility coordinators and then sign a learning agreement (LA). Access to the course catalogue is needed for this process. It is quite common that the learning agreements change before and during the mobility (which is already reflected in the official format of the LA document) so supporting the automatic change notifications helps to govern the process and lower the involved administrative burden.

The receiving institution should send a transcript of records with the student's achievements to the sending institution after the study period. This process, even if started by the receiving institution, may on the technical level be carried out in the same way as in the EMREX scenario. The ELMO file contains information on courses, credits, grades and grade distributions. The PDF version of the document included in the XML file may be signed with the personal qualified certificate of the person triggering the data transfer from the SIS of the receiving institution.

Student stipends are calculated on the basis of the length of the study period which is calculated from the arrival and departure dates to/from the receiving institution. These dates are sent on demand from the receiving to the sending institution.

EWP is based on APIs (*Application Programming Interfaces*) — a set of clearly defined methods of communication between various software components used to build applications. The API describes the expected behavior and may have multiple implementations. There are many APIs supporting the EWP business model:

- Primary Network APIs (Discovery Manifest, Echo, Registry),
- General Purpose APIs (Institutions, Organizational Units, Courses),
- Erasmus Mobility APIs (Interinstitutional Agreements, Outgoing Mobilities, Outgoing Mobility Change Notification Requests, Nominations Approval, Mobility Arrival and Departure, Transcripts of Records).

The specifications of the APIs are publicly available in GitHub (https://github.com/erasmus-without-paper). The page https://developers.erasmuswithoutpaper.eu/ is a guide for developers and should be visited first.

EMREX is implemented as one API.

The EWP business scenario is much more complex than the EMREX business scenario since it covers the whole Erasmus+ mobility process from the start to the end. There are many APIs, but each of them is relatively simple and can be implemented separately from the others. This is an important observation since it means that APIs may be implemented one by one gradually building support for the whole process.

EWP may need some user interface to start processes in one institution but the APIs invoked may be handled automatically on the other side without human intervention although most often at some moment the workflow will involve humans.

Both partners — the sending institution and the receiving institution — may start the process. There are APIs for sending (pushing) data and for requesting (pulling) data in response to change notifications. In theory, it is possible to handle EWP data exchange fully automatically by subscribing to notifications and firing triggers when they come.

For example the institution which changes data incorporated in the institutional fact sheet might broadcast the change notification to all subscribers — partner institutions which subscribed to this particular change notification. The obtained new version might be accepted automatically, stored in place of the old one, and displayed on the local web pages.

Integration of the EWP APIs in local processes needs careful analysis and taking into account local regulations and the cultural context. However, the detailed scenario for processing the transferred data in the local system is outside the scope of EWP. An exchange of ideas and best practices can help in choosing the best options. EWP — like EMREX — focuses on building the platform for the exchange of data. In the case of EMREX it means a static registry and one API, in the case of EWP a dynamic registry and the set of APIs (see Figure 2).

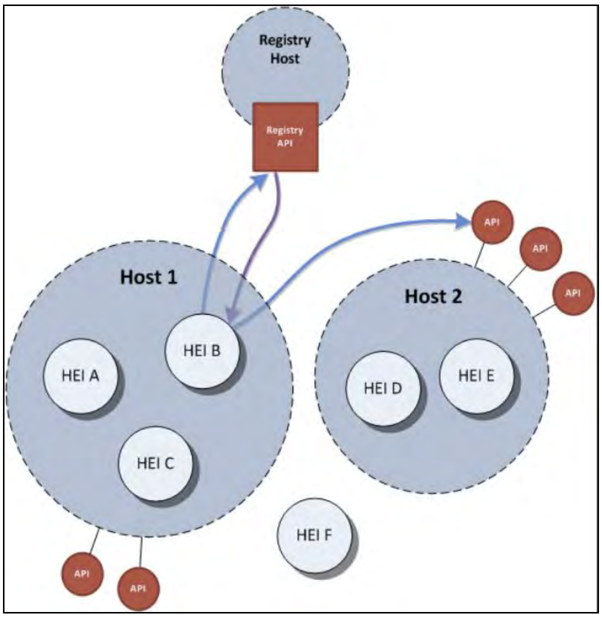

Figure 2 Main components of the EWP Network (from resources of the EWP project)

Although EWP, like EMREX, limits itself during the pilot to the most basic scenario, the designed architecture offers support for other scenarios. Along with the closed set of APIs for the exchange of mobility data, institutions may also offer open services, like common dictionaries (with e.g. countries, cities, institutions, postal codes, languages, Erasmus codes, PICs, ISCED codes etc.) as well as global statistics for some universally recognized and accepted ranking providers. The set of supported APIs may grow steadily, while the platform matures. By implementing new APIs the institution extends the set of offered digital services.

The data covered by the EWP data model is much more diverse than in the EMREX model. EMREX ELMO 1.1 is used for the part of the data covering learning agreements and the transcripts of records.

Privacy issues are solved in a different way than in EMREX. The student is the ultimate owner of his data but by applying for the mobility he authorizes both the sending and receiving institutions for data access, processing and exchange. In some countries (e.g. Norway) he should still in some way be involved in the process, for others (e.g. Poland) initial agreement at the start of the mobility is a sufficient condition. The **Groningen Declaration Network** (http://www.groningendeclaration.org) has a *Privacy Task Force* that is looking into the issue of how student data can legally be exchanged between HEIs

But also in the EWP model it is possible for the student to authorize the institution explicitly to exchange data on his behalf. In Poland there is a central registry of the results of the maturity exams. The maturity exams are carried out by so-called Regional Examination Commissions. Each high school student may authorize its Regional Examination Commission to send his maturity results to the central database called KReM. Then the high school student may authorize the admission system of the HEI to get the data from KReM on his behalf. The student cannot do it by himself since (for many reasons) KReM does not keep accounts for students, only for the administrators from Regional Examination Commissions and HEIs. Admission systems exchange data with KReM via a set of APIs. This scenario is in line with the EWP model of data exchange.

EWP supports the idea of one central API directory — central binding list for all applications which want to talk to each other using the commonly agreed protocol. We started building this directory by delivering APIs for the EWP user scenarios. The next step may be to add to it the EMREX use case, and eventually all APIs implementing digital services for the higher education area. Even if institutions do not have the mobility module or have to postpone building their own connector to the EWP platform, they may still benefit by using the binding service of the EWP registry.

In Poland there are over 50 HEIs using the same Student Information System. This SIS consists of a portfolio of web applications. We are considering using the EWP registry for the dissemination of information on the active installations of these web applications.

4. SUMMARY

Let's sum up the most important issues.

Both EMREX and EWP are platforms for the electronic exchange of data belonging to the business domain of the higher education institutions.

The EMREX platform is open in that respect because the institutions do not need to register to get data via EMREX. In fact it is the student who gets the data. EMREX just helps the student to transfer them in a secure and trustful way to the other system. The student uses a web interface (the EMREX client), which gets the URL of the National Contact Point (NCP) from the registry and redirects the student there. The student logs into the NCP as he would do going there directly. The registry which stores URLs of all NCPs solves the binding problem. It has to be based on trust, however — only trusted data sources can be added to the registry. Some governance policy is needed for admitting parties to the EMREX network.

EWP is open in another way — by offering a number of public APIs which can be invoked by any institution. Other APIs, in particular those supporting Erasmus+ mobility, need authorization. EWP, like EMREX, has to be based on trust and therefore needs a policy for accepting the new partners. It is up to the client to decide if the services offered by the EWP server are trustable and it is up to the server to decide if it is willing to offer services to a particular EWP client.

EMREX as of 2017 supports a simple scenario that has been tested in a live field trial. The findings of the trial can be used to elaborate practical issues which have emerged. In particular those findings may be of use for other projects involving data exchange. For example as part of EMREX the developers had to solve the problem of mapping local achievement data into the common ELMO data model and in particular agree on the data types, mandatory/optional fields and global identifiers. This provided EWP with a ready solution for the API responsible for transferring the transcript of records. This is a good example of how projects can benefit from each other.

The development work needed to benefit from the existing set of NCPs may be small. In particular any system where the data owner has an active account, like admission systems or portals with job offers, might connect to the registry and redirect the student to the NCP to get the data.

EWP as of early 2017 is under development with the aim to deliver a pilot solution at the end of the project. The pilot version will support all scenarios of the Erasmus+ mobility, which need to be integrated with the local SIS of the partner institutions. On the one hand it means more development work but on the other it offers better support for the administration. Any system can enquire the EWP registry for available services and can incorporate supported APIs into the local processes. The more elaborated those processes are, the higher the benefits, but it also means that more development effort is needed.

Both projects base their solution on one central element — the registry. The current design of the EMREX registry is based on the manual updates of the entries which change in time. The EWP registry stores more data which may change more often so it has been designed as self-updating on the basis of the Discovery Manifest files (services) stored (offered) on (by) the EWP hosts. Remote updates are secure and fast. In fact the EWP registry might also offer information on the available EMREX NCPs. If the same trust policy would govern acceptance of the new partners for both projects, the community would benefit from one solution for both sets of digital services.

The EWP data model covers more data than the EMREX model. However, both data models are based on ELMO in the scope of courses, grades, and credits which constitute a transcript of records. It is crucial — for both projects as well as other initiatives involving data exchange — to keep the data models compatible and base it on the same data standard (ELMO in this case). If ELMO is not shared among European digitalization services it runs the risk of becoming reduced to a niche (closed) data format. Both projects should give the world a real signal that it is a good idea to base data exchange on that format and make it the de-facto standard or at least reuse naming conventions.

What is the most essential difference between the scenarios supported by both platforms? In my opinion it is the responsibility and ownership of the business process. Does this lie with the student or with the HEI administration? Who starts? Who is in charge? Is the student responsible for the timely delivery of its nomination to the partner institution? No. Is he responsible for the timely delivery of the transcript of records to the student's office? Yes or no — it depends on the regulations which are in place in the sending institution. Both EMREX and EWP may be used to transfer transcripts of records, diploma supplements, and course catalogues but in a different user scenario. EMREX will not be used — as EWP will — to transfer data on the mobility to the Mobility Tool+ of the European Commission since a student is not part of the process. EWP will not be used to send student credentials to the job portal, at least not unless authorized by the student, since this is not the task of the administration. EWP may share student data between institutions which by law are authorized for processing student data. EMREX may share student data between any institutions under the condition that the student controls the process. EMREX needs eID or an equivalent solution for the authorization problem. EWP needs a clear statement concerning privacy issues.

By implementing EMREX an institution extends the set of electronic services for a student, while by implementing EWP it supports its own administrative staff and daily routines of staff members.

5. DISSEMINATION, SUSTAINABILITY, EXPANSION

Institutions of higher education need both platforms to diversify their offer to the community and be regarded as valuable mobility partners. However, you need two to tango. When the institution implements data exchange, it might encourage its mobility partners to do the same. The readiness for digital data exchange might be a good measure for the quality of the partnership in the mobility.

Partners in the projects will use the developed solutions in their production systems showing by example how the process can benefit from even the simplest digitalization services. This will be the best practical support for the dissemination.

Scalability can either be obtained by building central data repositories which can offer services to many institutions (centralization of the service) or by designing the local solution for one institution and deploying it in many institutions — like it is the case in e.g. Italy and Poland which have developed Student Information Systems for many higher education institutions (distributed services).

In IT projects the most important issue is sustainability. If you are going to base your SIS on some external platform or data format you have to be sure that the platform will not stop running and that the data format will be backward-compatible. Somebody should take care of the developed software solution. If it is built in-house your own development team will be responsible for the maintenance. If the system is delivered by a commercial provider you have to make sure that the provider will take care of this.

Both projects are currently funded by the European Commission, which means that common software is open-sourced. In both cases the technical results of the projects are stored in GitHub. Design decisions can be followed there, the source code can be consulted and reused. However, some sustainable support for newcomers may further ease the decision to join. Institutions might be encouraged to share the ideas and experience, scenarios and technical solutions, good practices and real life scenarios, and even the regulations which govern the data handling. In many cases supporting mobility is not a technical problem, but a problem of different regulations and processes. A competence center offering such kind of support might be a good option.

It is tempting to further expand the services but it might be more reasonable to first make it more mature and elaborated, to make them recognizable as standard services offered by the community of HEIs.

6. FINAL CONCLUSIONS

Here are some final guidelines.

The results of both projects should be available as a common platform with a complementary set of digital services. The registry with the binding information about available digital services might be shared. Security issues should be handled in the same way.

Acceptance of the new partners might be based on the same policies. Building trust that the delivered data is of good quality and is offered by the authorized data providers is crucial.

Common dissemination events might be offered to the community and help in building such trust. A good example is the Groningen Declaration Network which since 2012 has managed to build a global network of signatories devoted to the idea of digital student data portability.

Data models for both platforms should be based on a common data format and common converters to other formats (e.g. those of PESC in the US) should be made available. ELMO should be further developed into the de-facto mobility standard and should support more types of student mobility processes.

GitHub repositories will continue to give access to the design and implementation decisions and the common code. Institutions will gradually elaborate and extend the set of offered services, depending on their priorities and technical abilities. Other digital services, resulting from the new European IT projects, can also be incorporated. The projects will then cooperate in delivering a common platform of digital services for higher education.

There may be different scenarios and workflows based on the cultural context but there should be one common platform for data exchange as there is one common network protocol.

There should be one digital EHEA for all.

7. ACKNOWLEDGMENTS AND DISCLAIMER

EMREX and EWP are designed and implemented by partners coming from various European countries but sharing the long-standing and profound belief that in the digital era student data should be exchanged electronically, not on paper.

Some of the statements formulated in this paper are subjective and as such should be regarded as the opinion of the author.

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9. AUTHOR BIOGRAPHY

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“Support student mobility with the European Student Card project”

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Keywords
Student services; student mobility; student information systems; digital exchange; European experimentation; ID and status recognition; EMREX; EWP; Erasmus+

The presentation will trace the history of the project, give a clear picture of the state of work (technical implementation) and the expected results.

1. INTRODUCTION

In a Europe beset by crisis after crisis, youth mobility is more than ever proving a catalyst in bringing people together by fostering greater intercultural dialogue and an outward-looking mentality. In order to tackle the obstacles to such mobility, the aim is to make better use of the opportunities provided by the Erasmus+ programme and to increase student mobility in the European Higher Education Area (EHEA).

The European student card (ESC) is based on the recognition of the student identity and status regardless of institution, in accordance with each country's specific procedures. ESC aims to promote cooperation between institutions and reciprocity of rights and services for students.
Starting with the co-operation between European student service organizations and in particular the Franco-Italian dialogue (agreement signed in Rome in April 2013 between the Endisu Foundation and the Cnous, in presence of the President of the Italian Rectors Conference), the project ESC was structured by the signing in January 2016 of a "Memorandum of Understanding" between the student services organizations in Italy, France, Germany and Ireland and the implementation of technical working groups.
In this context, the signing organizations are launching a technical platform for data and service sharing, which will launch initial experiments on the project in several territories: the Educatt network (Milan, Piacienza, Brescia And 40,000 students), ESU Padova (65,000 students), Royal Surgeon College in Dublin (3,500 students), Besançon (22,358 students), Strasbourg (55,500 students), and the cross-border European campus Eucor (115,000 students).

The 9 core partners (Cnous, Deutsches Studenwerk, Fondazione ENDISU, EDUCatt, ESU Padova, Studierendenwerk Karlsruhe, Crous Besançon, Strasbourg Crous, Confederation of student servicesin Ireland) committed to develop the European student card by supporting this project

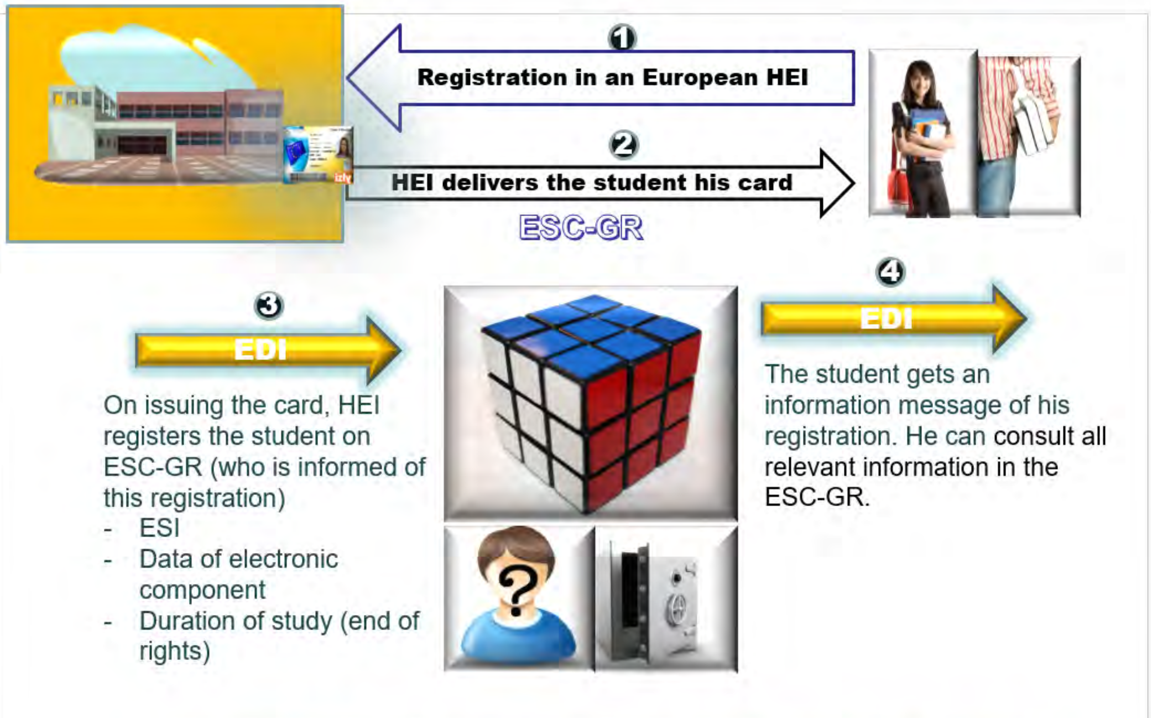
within the EU institutions within the framework of the Erasmus + program and by continuing to structure partnerships with (ECStA, Erasmus Without Paper, Erasmus Student Network) and with academic partners, with a view to its gradual extension to other institutions and countries.
Currently 117 associated partners join the project.

2. PROJECT GOALS

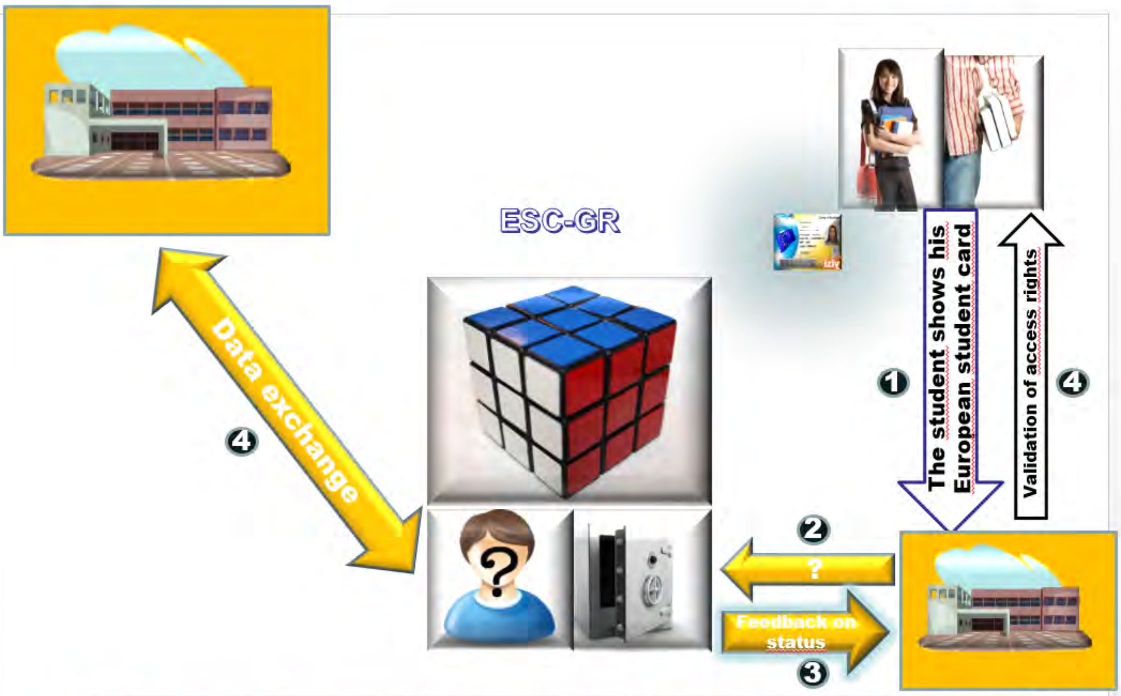
The project aims to promote student's mobility by interconnecting the information systems of the higher education institutions adhering to the system in order to allow the recognition of student status and identity which will allow him to access to services on campus. The innovative character of the project resides in the fact that:

- While other private associations or companies have previously proposed similar projects to enhance student interconnectedness, this project differs by being operated directly by HEIs.
- It's an open system built step by step, based on the free adherence of the institutions.
- the project taked into account the various characteristics of the information systems of every country even of every HEI or player concerned by students (bottom-up approach)
- After the pilot phase, and following confirmation that all systems are working as required, an extension to the European area will be proposed. Institutions will have the opportunity to opt in.
- it's open to every student

Overview
From creation process of the card
to recognition of student status

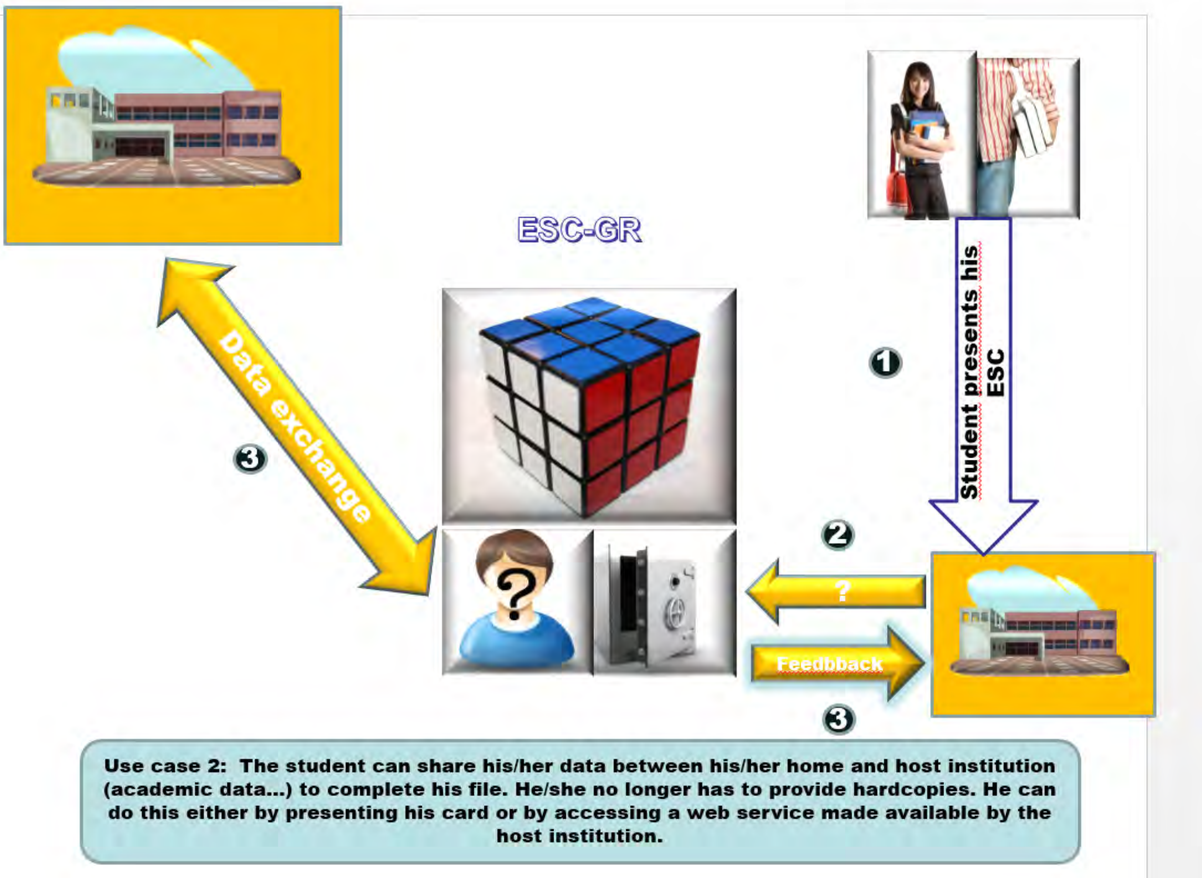


Step 2: The student is registered on ESC-GR as long as he studies (with a possible extension - procedures have to be defined in case of gap years)



Use case 1: The student wishes to assert his/her rights during a mobility (or as part of binational studies) between several institutions (EUCOR).

Objective: improve the trust in this system (card) and opening rights based on this trust (restauration, library, building access...)



3. STATE OF WORKS

Currently the partners are working on 4 dimensions of ESC:

The recognition of the student status and identity (common and basic use of the card) and the development of the exchange platform between the institutions.
The management of a digital identity of the institutions and of the students will be a common denominator of the ESC, the Erasmus without paper project and the Emrex project.

1. Access to services with a payment (vending machine, catering, copy machine…)

- EUCOR works between Strasbourg and Karlsruhe are very advanced about the electronic wallet IZLY. They are working on the possibility to recognise and use the wallet in both cities.
- Berlin territory: works with Campuscard Berlin (CCB). CCB, it's 150 000 students, 6 universities. They have an electronic wallet and intend to work on the adaptation of Izly to their card system.
  - The next meeting will be held in Berlin on 23.02.2017.
  - A MOU will be signed at this occasion.
  - CCB will experiment services with French universities from September /October 2017.

→ Electronic wallet not compulsory
→ Important to open access to visiting student to use any service with a payment

2. Access and use of libraries: this had been identified as a priority by the partners. EUCOR, the European Campus had first discussions about it.

3. Cooperation with Erasmus without paper project: Integrate paperless administrative Erasmus mobility:

4. Cooperation with EMREX project to integrate the transfer of student's records between EU institutions.

Over the next two years the platform will be trialled with the Educatt network (consisting of 40 000 students in Milan, Piacenza, Brescia and Rome), several Irish universities, Crous and the University of Franche-Comté, Besançon (22 358 students), Crous and the University of Strasbourg (55 500 students) – all full members of the Erasmus+ strategic partnership – in addition to Eucor and, potentially, additional partners from other countries (for example MOU signed with Campus card Berlin – experimentation of real mobilities from September 2017).

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5. BIOGRAPHIES

Jean-Paul Roumegas has a Master Degree in French literature. He is post-graduate in European studies course in the French administration School (ENA). He was in charge of the educational and higher-educational affairs in the French Embassy in Mexico from 1995 to 1999 and on the same functions in the Embassy of Brazilia from 1999 to 2003. In 2003 he became Director of international affairs in Cnous and since January 2016, he is counsellor for International relations & partnership in Cnous. He is also project coordinator for the European student card.

Frédérick Bigrat has a Master of Science (M.S.) in Information Technology. He is actualy PhD Student in Information Science and Communication in the French University Panthéon-Assas (Paris II). Military Soldier in the French Land Army from 1990 to 2005 as Network and System Engineer, he joins respectively the French Institute of Research for Development (IRD), in 2007 the French Commission for Atomic Energy (CEA) and in 2010 the French University Paris I Pantheon-Sorbonne as Project Leader. Since 2014, he is the Chief Digital Officer of Sorbonne University. He is also the Representative of the French National Student Card Committee and the Leader of the EUNIS Student Card Task Force (http://www.eunis.org/).

ABSTRACT

DIGITAL DIPLOMA DATA (*IN DEUTSCHLAND?*)
Exchanging diploma data digitally instead of on paper

DUO (Dienst Uitvoering Onderwijs) is the executive agency of the Dutch Ministry of Education Culture and Science. DUO manages digital registers with student data. All state funded schools and universities in the Netherlands are obliged to send their student data to DUO, safely and digitally. DUO also uses these data to reduce the administrative burden of students and educational institutions by supporting the enrolment processes. DUO and all its chain partners realised this process for higher education in 2013, with Studielink as the national enrolment portal. The results are very positive: a faster process, the use of secure digital data, and a major reduction of costs. DUO also contributes to the EU 2020 policy target that 20% of higher education students is mobile. Therefore DUO has set up a programme for 2017 to support cross border enrolment with digital diploma data experimenting with 3 different methods:

- SFTP: 1:1 exchange of pdf's through Secure File Transport Protocol
- EMREX: a network for exchanging diploma data in xml (Erasmus+ project)
- eDelivery: a EU project for secure file transport in Europe.

Since about 40% of foreign students in the Netherlands come from Germany and because a lot of Dutch students study in Germany it would be very appropriate for DUO to engage in projects with Germany. Who in Germany dares to join us?

DIGITAL DIPLOMA DATA (*IN DEUTSCHLAND?*)
Exchanging diploma data digitally instead of on paper

1. INTRODUCTION
The purpose of this document is to present information about projects which support the European aim of increasing international mobility of students. One of the main obstacles for this mobility is the administrative burden: when applying for an international study, students have to submit a significant amount of documents, both originals and copies. The key document is, of course, the diploma.

The projects we present in this document deal with replacing paper documents with secure digital ones. In the Netherlands, incidentally, this has already been realised in 2013. Since then, no paper whatsoever is involved in the process of enrolment in higher education.
The goals of the projects are:
- Contributing to the EU 2020 policy target that 20% of higher education students is mobile
- The prevention of fraud
- The reduction of the administrative burden of students and educational institutions
- A quicker administrative process
- Cost reduction.

This document starts with an introduction of DUO. After that we will cover the Groningen Declaration and the projects that have emerged worldwide.

2. DUO
DUO (Dienst Uitvoering Onderwijs) is the executive agency of the Dutch Ministry of Education Culture and Science. DUO executes laws and regulations for the Dutch education system. Its core business is providing student loans and financing educational institutions. To support this, DUO manages digital registers with student data. All state funded schools and universities in the Netherlands are obliged to send their student data to DUO, safely and digitally. DUO also uses these data to reduce the administrative burden of students and educational institutions by supporting the enrolment processes. DUO and all its chain partners realised this process for higher education in 2013 with Studielink as the national enrolment portal. The results are very positive: a faster process, the use of secure digital data, and a major reduction of costs.

3. DIPLOMA REGISTER AND GRONINGEN DECLARATION
In 2012, DUO made the Diploma Register available online. This virtual register contains the diploma data of various digital registers DUO keeps, from secondary to higher education. Everybody who has graduated in the Netherlands can access the Diploma Register via the Dutch digital identification service DigiD. The alumnus can check his diploma data online and download a free extract of his diploma data in the form of a secure pdf (with a digital signature of DUO). The extract can be used when a certified copy of a diploma is required. This way DUO helps to prevent fraud and reduces both alumnis' and employers' administrative burden.

When the Diploma Register was presented in April 2012, DUO organized an international conference which was attended by managing bodies of diploma registers from all over the world. At the conference, (almost) all parties present signed the Groningen Declaration (GD). The GD is a declaration of intent to support international mobility of students by using digital (national) data. DUO supported the GD by running its secretariat until 2016. Since 2012 an annual conference is organised (2013 Beijing, 2014 Washington, 2015 Malaga, 2016 Cape Town). This year the GD-conference took place in Melbourne.
Over the years, many more organizations have signed the GD. All around the world activities within the framework of the GD have been initiated, for example in Scandinavia, Italy, Poland, the US, China and Australia.

4. DUO PROJECTS

In 2015, the Ministry of Education Culture and Science established a Steering Committee International which governs Dutch initiatives within the framework of the GD. All chain partners involved in the process of international enrolment participate in this committee. On behalf of the Netherlands, DUO has explored the possibilities for pilots that will facilitate the enrolment process of international students in Europe, but also in China. The Steering Committee International also requested DUO to explore various methods and ways of working.
This resulted in the following programme for 2017:

- Sending PDFs through SFTP with partners in China, Flanders and Germany;
- Joining the EMREX network;
- Participation in an EC project for e-Delivery.

The programme will be amplified in chapter 5.

Both the SFTP-process and the EMREX-process aim to support the international mobility of students, to prevent fraud, and to make life easier for students and university staff members. This way DUO and all its partners contribute to the EU policy of increasing student mobility.
A further benefit is the reduction of costs. A 2011 study showed that the enrolment of one foreign student costs about € 400[1]. Furthermore, foreign students tend to apply at several universities simultaneously, so a lot of work at the universities is done in vain. When universities will receive the diploma data digitally from a trusted source the process of enrolment will become easier and faster and therefore cheaper[2].

5. THREE METHODS: SFTP, EMREX AND E-DELIVERY

5.1 SFTP: Secure File Transport Protocol

The Secure File Transport Protocol (SFTP) is a secure 1:1 internet connection which is very suitable for sending pdf-files.

In 2016, DUO started a pilot project with China for Chinese students coming to the Netherlands. It involves the Chinese diploma register CHESICC, three Dutch universities, a large number of Chinese students, and DUO. In this process DUO received Chinese diploma data (English translation) in the form of a pdf directly from CHESICC.
Each year about 6,000 Chinese students enrol in Dutch universities. The enrolment process is very elaborate and involves the translation and verification of diplomas, the exchange of paper documents and scans, and the checking of all these documents.

The SFTP process is initiated by the student and works as follows (figure 1):

1. A Chinese student applies at the website of the Dutch university
2. There he receives a student number and a link to CHESICC
3. He identifies himself at CHESICC and collects his data (verification reports translated into English in pdf)
4. The student gives his consent to CHESICC to have his data sent to the Netherlands, and CHESICC sends the data via SFTP to DUO

5/6 DUO passes the data to the university involved.

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[1] Eindrapportage Rode Loper Studielink, Projectgroep Rode Loper Studielink, 06-10-2011, s.l. (Final report of project aimed at facilitating the process of enrolment of foreign student in the Netherlands. The proposals suggested in the report were not implemented because the universities were unable to reach agreement. On page 6: "(…) kosten voor studenten uit bijzondere doelgroepen zoals internationale studenten, tussen de € 350 en € 450 per student liggen". Translation: "(…) costs for students from special target groups such as international students are among € 350 and € 450 per student".

[2] Eindrapportage Rode Loper Studielink page 6: "Instellingen die aan het onderzoek hebben deelgenomen, gaven aan 25-30% te kunnen besparen op de uitvoeringskosten (…)". Translation: "Institutions participating in the research indicated to be able to reduce the costs with 25-30% (…)".

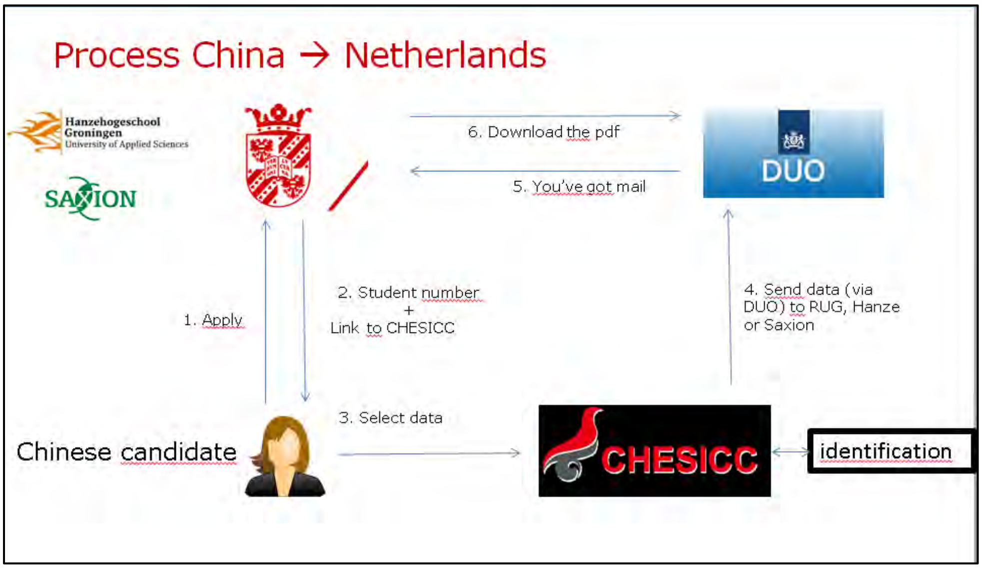

Figure 1 SFTP process CHESICC – DUO

The pilot had 3 goals:

1. Are the CHESICC transcripts of use to the Dutch universities.
2. Do the Chinese students want to participate in this process
3. Working together with CHESICC.

The pilot was a great success. The three universities were able to test the communication with the Chinese applicants and the usefulness of the data in the transcripts CHESICC offers. As a result they have accentuated the information for the Chinese applicants, for now the universities now exactly which transcripts the students have to select at CHESICC. The Chinese students prove to be very willing to participate in this digital process. And the cooperation between CHESICC and DUO was efficient and easy-going.

In 2017 this project is continued and 9 more Dutch universities participate.
DUO will simultaneously start similar projects with Flanders (involving the Flemish agency AHOVOKS and three Flemish universities), with China (for Chinese students returning to China who need to have their Dutch diploma validated by the Chinese authorities) and with Germany (see chapter 6).

5.2 EMREX

EMREX is an Erasmus+ project. EMREX is the solution for electronic transfer of student records between higher education institutions in Europe. The EMREX field trial aims at testing new ways to make the administration of student mobility easier, promoting higher attainment level to student mobility in higher education, encouraging more effective recognition of prior learning and avoiding overlapping studies. In the first phase the trial (figure 2) is set-up between four Nordic countries (Norway, Finland, Denmark and Sweden) and Italy. The electronic transfer of the student achievement is initiated by a student's approval through the Student Mobility Plug-in (EMREX client), installed in the student web / the student portal at the home university. The student records are then fetched from the National Contact Point (NCP) of the host university in question. In 2017, the service is available for higher education institutions in the Nordic countries, Italy and Poland. These countries test and evaluate the functionality and the impact of the solution.

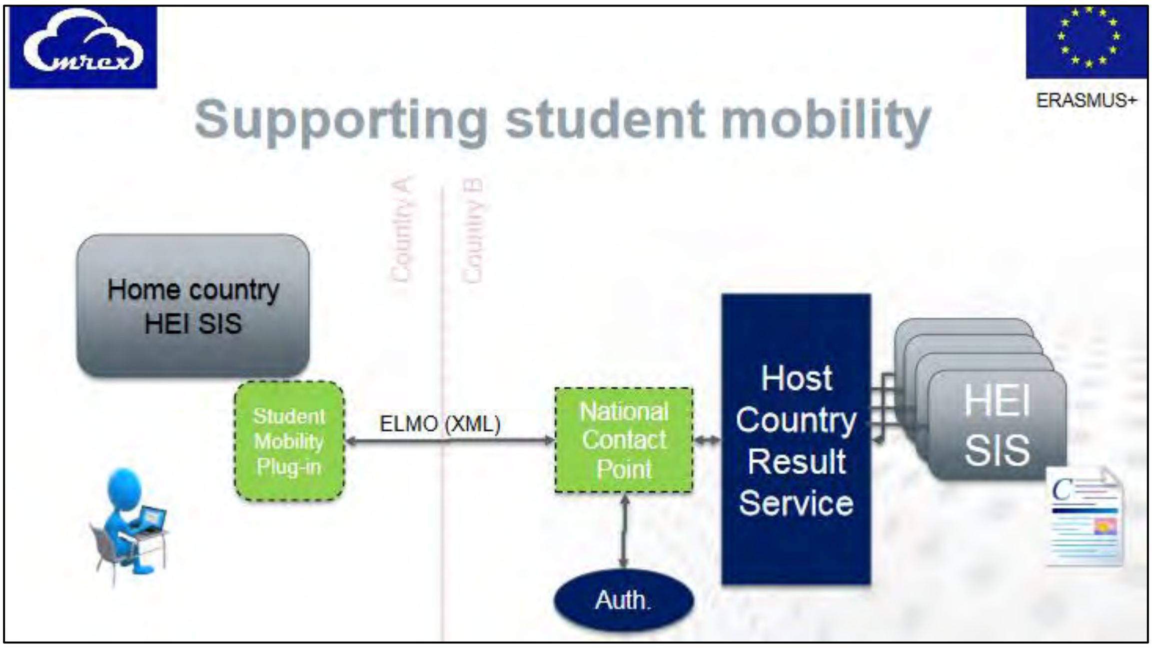

Figure 2 EMREX process

DUO will join EMREX in 2017. From that moment on, students from all participating countries will be able to send their diploma data through the EMREX platform to the Dutch university of their choice. And Dutch students can send their diploma data to a foreign university. The data are machine readable (xml) and can be imported (directly) into the universities' databases.

5.3 e-Delivery

e-Delivery is one of the building stones of e-SENS, a combination of EU Large Scale Projects. The aim of e-SENS is to facilitate the deployment of cross-border digital public services through generic and re-usable technical components, based on the building blocks of the Large Scale Pilots. The consolidated technical solutions, with a strong focus on e-ID, e-Documents, e-Delivery, Semantics and e-Signatures, aim to provide the foundation for a platform of "core services" for the eGovernment cross-border digital infrastructure foreseen in the regulation for implementing the Connecting Europe Facility.
e-Delivery helps public administrations to exchange electronic data and documents with other public administrations, businesses and citizens, in an interoperable, secure, reliable and trusted way. Through the use of this building block, every participant becomes a node in the network using standard transport protocols and security policies.

On behalf of Dutch governmental institutions a connection to the e-Delivery network is established as proof of concept in 2017. DUO is part of the consortium and will provide the e-Enrolment process as a use case.

6. GERMANY

The Steering Committee International has urged DUO to seek German participation in the GD projects, because 40% of foreign students in the Netherlands come from Germany, and because a lot of Dutch students study in Germany.
It proved to be very difficult to find suitable partners in Germany. There are no Diploma registers in Germany, the enrolment processes are paper based and Germany is very sensitive in privacy matters. But since the rest of the modern world can deal with these issues, why not Germany?
Thanks to the networking activities of the secretary of the GD, in October 2016 DUO was invited to the Stiftung für Hochschulzulassung (SfH) in Dortmund and the Bundesministerium für Bildung und Forschung (BMBF) in Berlin. DUO staff members informed the German hosts about security measures, the Dutch Diploma Register and the digital enrolment procedures in the Netherlands. This resulted in a request from the BMBF and the Hochschulrektorenkonferenz for DUO to initiate projects on digital enrolment with German universities, and in the initiative of the SfH to start a project with DUO.

6.1 Project with the Stiftung für Hochschulzulassung using SFTP

This project facilitates the participation of Dutch applicants in the “zentrales Verfahren” for the selection of applicants for medical studies in Germany. The process is very similar to the process used by DUO and CHESICC.
DUO and the Stiftung für Hochschulzulassung (SfH) are aiming at this procedure (figure 3):

1. A Dutch student applies for the selection process at the website of the SfH
2. There he receives a student number and a link to DUO
3. He identifies himself with DigiD (Dutch digital ID) and selects his diploma data
4. The student gives his consent to DUO to have his data sent to the SfH, and DUO sends the data via SFTP to SfH.

The SfH then uses the data in the “zentrales Verfahren”.

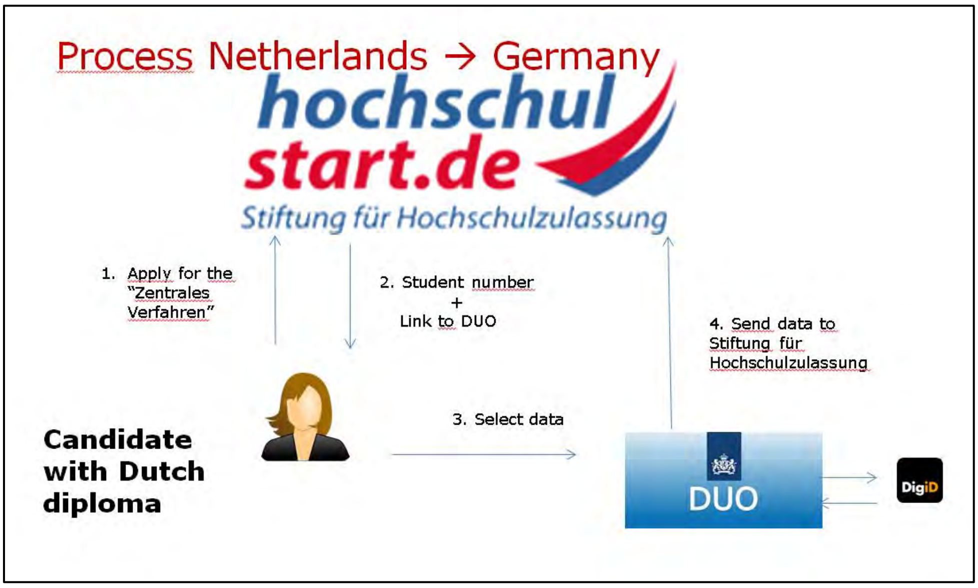

Figure 3 SFTP process DUO – Stiftung für Hochschulzulassung

6.2 The EMREX process in Germany

DUO is the National Contact Point (NCP) for the Netherlands. Therefore, Dutch students using the EMREX-client (Student Mobility Plug-in) of a foreign university will be directed to DUO, where they can select their diploma data. EMREX can be used for Dutch students who intend to study in Germany.
Once German universities use EMREX, they can apply this process for students coming from all the countries participating in EMREX. This is a very strong feature of EMREX.
Another strength of EMREX is that the EMREX client (Student Mobility Plug-in) is very easy to implement.

At the moment of writing this paper the management of the Hochschulrektorenkonferenz is looking for German universities to participate in a project with DUO.
Figure 4 shows how the EMREX enrolment process with a German university could look like.

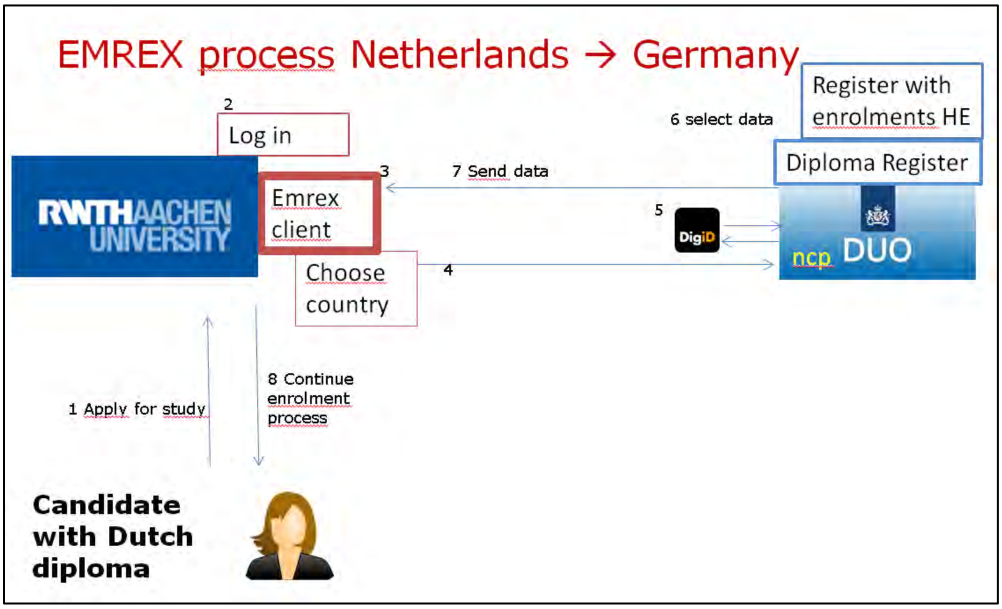

Figure 4 EMREX process DUO – German university (example Aachen University)

The EMREX process for a German university works like this:

1. A Dutch student applies for enrolment at the website of a German university
2. The student identifies himself and is redirected to the EMREX client (Student Mobility Plug-in)
3. There he chooses the country where he received his diploma (in this case the Netherlands)
4. He is redirected to the NCP of that country (in this case DUO)
5. He logs in at DUO via DigiD (Dutch digital ID)
6. At the NCP (DUO) he collects his diploma data (in this case at the Diploma Register)
7. By pressing a button he will send the diploma data to the EMREX client of the German university.

7. CONCLUSION

Experiments with projects for cross border enrolment using digital diploma data are in full swing in the Netherlands. The SFTP method proves to be very easy applicable and is appropriate to test whether the transcripts that can be exchanged between countries are useful.
EMREX is a more sophisticated approach and Dutch universities are very eager to try it out.
e-Delivery seems to be more suitable for a back office process like the check on actual enrolment for students who receive student loan from their home country. This check can be executed without the individual consent of the student, because there's a legal ground for it.
In the meantime new methods have appeared, like block chain technology. The Flemish and Dutch authorities are now sensing the prospects of this approach.
We think at the end one or two methods will remain. And as we see it now EMREX will be one of them.

ADDENDUM (June 2017)
The abstract for this paper ends with the words "who in Germany dares to join us?".
We already have an answer to that question.

Just a week before the EUNIS conference uni-assist decided that they will implement the EMREX client in 2019. Uni-assist is the "University Application Service for International Students."
Uni-assist processes applications from international students on behalf of 182 German higher education institutions. Uni-assist performs preliminary processing and evaluation of the applicant's university entrance qualification materials, running a check of the applicants' certificates to determine which grades they have on the German grading system. This preliminary evaluation

informs applicants whether they qualify to study all subjects (general qualification) or only certain subjects (subject-restricted qualification).

From the moment on that uni-assist has implemented the EMREX client (Student Mobility Plug-in) the process for the enrolment of 182 German higher education institutions could look like is shown in figure 5.

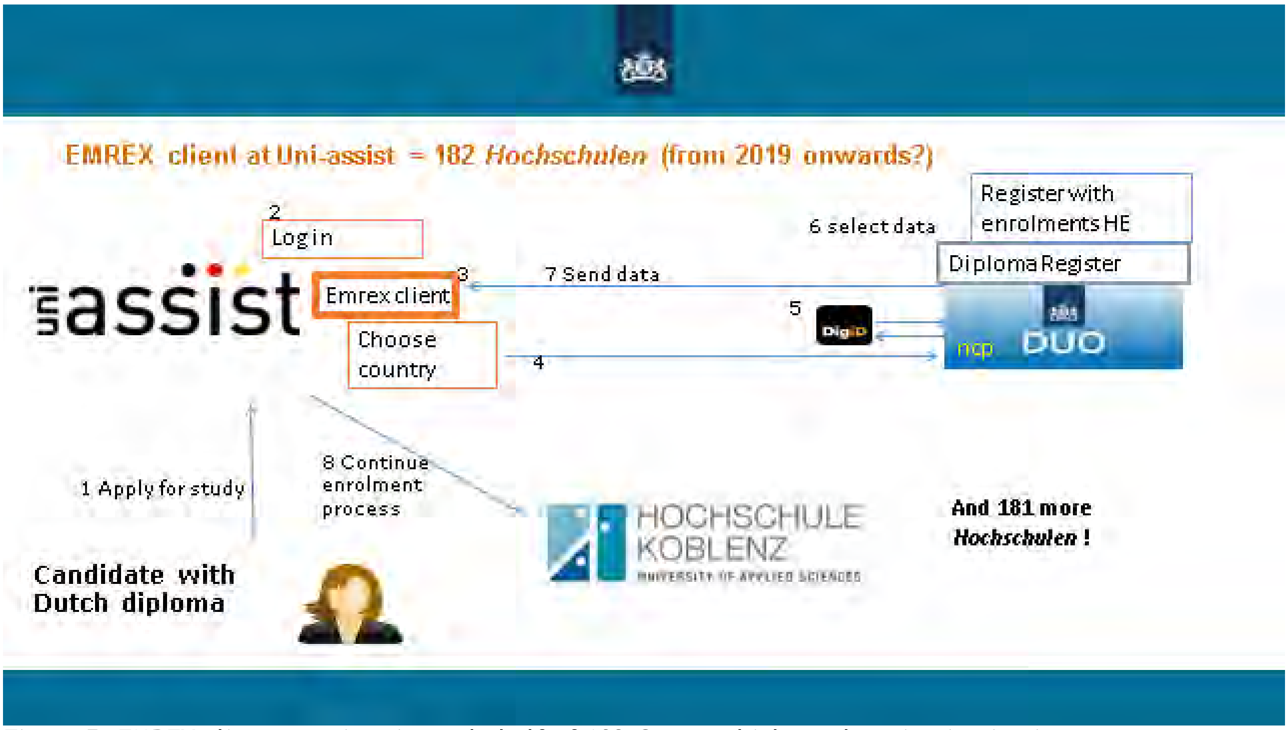

Figure 5: EMREX client at uni-assist on behalf of 182 German higher education institutions.

The EMREX process than would work like this:

1. Person with Dutch diploma applies at website of uni-assist for Hochschule Koblenz
2. Applicant identifies himself
3. Applicant is redirected to EMREX client (Student Mobility Plug-in)
4. Applicant chooses Dutch NCP (DUO)
5. Applicant identifies himself at DigiD
6. DUO receives Burger Service Number from DigiD (BSN; = Dutch social security number)
   DUO redirects applicant to Diploma Register
7. Applicant chooses diploma and sends his data to EMREX client at Hochschule Koblenz
   Applicant is redirected to EMREX client at uni-assist
   Applicant checks his data and sends it to uni-assist
8. uni-assist sends data through safe internet connection to Hochschule Koblenz
   Hochschule Koblenz contacts the applicant and continues the enrolment process.

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2016-now: K.A.V. Alcuinus: President of the student association for all Dutch students at the universities of Aachen.

DABAR - the national infrastructure for digital repositories

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digital repositories, institutional repositories, DABAR, digital asset management, DAM, data curation, open access, interoperability, electronic theses and dissertations, ETDS, Islandora

1. ABSTRACT

Having recognized the need for a national digital asset management infrastructure, SRCE – University of Zagreb University Computing Centre in association with a number of research and higher education institutions in Croatia built a national repository system called DABAR – Digital academic archives and repositories. DABAR provides research and higher education institutions with the common infrastructure necessary to establish a secure, reliable and interoperable institutional repositories in a simple way. Dabar allows institutions to manage their digital assets without the need to deal with technical issues related to the implementation and maintenance of digital repositories.

Until the middle of March 2017, DABAR was used to build two national repositories and 109 repositories of Croatian research and higher education institutions. Currently, it supports curation of electronic theses and dissertations, and papers published in electronic journals. The support for conference papers, book chapters, artistic works (photographs and other audio-visual objects) is being actively developed and a plan to build a support for managing research data sets and educational resources is in place.

The DABAR platform and the community gathered around it are actively promoting Open Access to the results of research and to educational modules and resources.

2. DIGITAL ASSETS MANAGEMENT AND OPEN ACCESS IN RESEARCH AND HIGHER EDUCATION COMMUNITY IN CROATIA

One of the first milestones in promotion and fostering of open access in Croatia was the announcement of the Portal of Croatian scientific journals, HRČAK, in February, 2006. Nowadays, HRČAK hosts more than 420 Croatian journals that publish full text articles in open access. The first time that "the principle of the openness to the public" in Croatia appeared in an official document was in 2006 in the *Science & Technology Policy of the Republic of Croatia* ("Znanstvena i tehnologijska politika Republike Hrvatske 2006. – 2010. godine", 2006). The document stipulated that the research and development results that had been funded by public funds had to be publicly available in open publications or open access databases. A couple of years later, in 2012, *The Croatian Open Access Declaration* was announced and signed by numerous institutions and individuals in Croatia. At that time, only a few institutions had a technical solution for archiving digital assets mainly based on EPrints software. The awareness about the need for the systematic approach to data curation in Croatia was still developing. The first digital repositories in Croatia were HRČAK, FAMENA PhD Collection, FOI digital library, University of Zagreb Medical School Repository, Faculty of Humanities and Social Sciences Institutional Repository and Full-text Institutional Repository of the Ruđer Bošković Institute FULIR. ("OA i OER u Hrvatskoj", 2013)

The importance of Open Access that brought together the scholarly community in Croatia was finally stated in *The Scientific Activity and Higher Education Act* ("Zakon o znanstvenoj djelatnosti i visokom obrazovanju", 2013), which requires universities and higher education institutions to permanently publish theses and doctoral dissertations in public databases (repositories).

Having recognized the Croatian academic and research community's need and aiming to enable it to fulfil its legal obligation, during 2014 SRCE initiated a network of numerous experts and scientists that were interested in digital repositories or had already been working on archiving digital assets for their institutions. Furthermore, SRCE established contact with numerous research and higher education institutions such as the National and University Library in Zagreb, the Ruđer Bošković Institute as well as other higher education and research institute libraries.

As individual institutional solutions for archiving and curation of digital assets were organizationally, financially and technically challenging, SRCE recognized the importance and advantages of building a national e-infrastructure for digital repositories. The vision of a national solution was welcomed not only by institutions that were under a legal obligation to establish digital repositories, but also by other institutions that saw the opportunity to collect and preserve their digital assets in one place.

In addition to the technical challenges in establishing digital repositories, research and higher education institutions were faced with organizational challenges in adopting internal policies and documents that entitle them not only to publish digital material created by their students and staff, but also to publish it according to the principles of open access.

On 4 March 2016, SRCE signed the memorandum of understanding with four institutions within the Croatian academic and research community: the Ruđer Bošković Institute, University of Zagreb School of Medicine, University of Zagreb Faculty of Humanities and Social Sciences and the National and University Library in Zagreb. The institutions agreed to foster organisational, informational and technical development of the national e-infrastructure for digital repositories – DABAR.

3. GOALS OF THE PROJECT

The main goal of the DABAR project was to build a robust and scalable national infrastructure for digital repositories that would enable research and higher education institutions to establish their own reliable and interoperable digital repositories. At the same time, this national infrastructure was expected to promote and follow open access principles.

Furthermore, each institution had to be able to build an institutional digital repository on the institution's internet domain. This was important especially to universities because the metrics that compare universities (e.g. Webometrics[1]) are based on the volume and quality of electronic publications available within universities' internet domain.

The technical requirements for DABAR were to provide a service that is:

- secure and reliable for long term preservation
- interoperable with other national and global infrastructures (e.g. Portal of Scientific Journals of Croatia, OpenAIRE, …)
- scalable (ability to support many institutions and large number and size of digital objects)
- sustainable
- flexible in the sense that it could be customized according to a particular institution's needs.

SRCE, as a major computing centre and the architect of the e-infrastructure for research and higher education community in Croatia, has taken responsibility for the development and maintenance of the necessary infrastructure, which includes: providing the networked computing resources and data storage, taking care of the security and reliability of the whole system and maintaining an application solution linked with appropriate middleware (national identity federation AAI@EduHr).

[1] http://www.webometrics.info/en/Methodology

From the very beginning, SRCE's plans included bringing together the wider community[2] to take an active role in shaping the services. Following tasks were planned:

- setting up working groups from the professional community, primarily advanced users of the system, which would take over the responsibility for:
    - the definition of the information needs of the community
    - the design and maintenance of common metadata profiles and controlled vocabularies
    - participation in education and support for the end users
- raising awareness about the importance of systematic preservation of research and higher education institutions' digital assets
- promotion of open access to research results and educational content.

At the same time, SRCE has aimed to establish its own sustainable and competent team for development, maintenance and continuous improvement of DABAR's services.

4. STATE OF THE DEVELOPMENT AND RESULTS OF THE PROJECT

As a result of the project, a service called DABAR[3] has been developed and released. DABAR is a part of the national infrastructure that enables a simple and free-of-charge set-up of a digital repository for all the institutions in the research and higher education community in Croatia. More information about the architecture and technical aspects of DABAR is provided in section 5.

DABAR's production started on 17 August 2015, and, by 17 March 2017, 109 digital repositories have been requested and set-up in the system. The amount of applications for the set-up of the repository is an indicator that the institutions have recognized the need for systematic management of their digital assets and DABAR as a solution to that need.

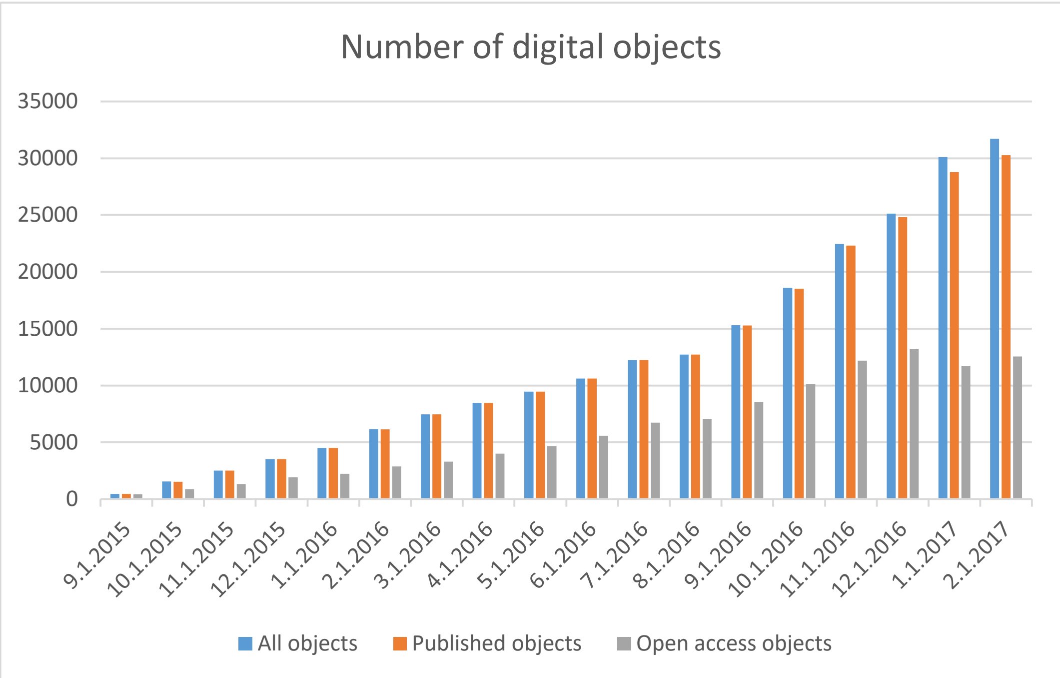

Figure 1. Number of digital objects stored in repositories in DABAR

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[2] https://dabar.srce.hr/en/partner-institutions

[3] https://dabar.srce.hr/en

SRCE has been periodically organising educational workshops for repository administrators. By 10 March 2017, a total of 14 workshops with 181 participants were held.

The National and University Library in Zagreb, in collaboration with SRCE and other higher education libraries, has defined metadata descriptions for digital objects “student thesis” and “dissertation and scientific master's thesis”. Those definitions were accepted at the national level, which ensures a high degree of interoperability and compliance with international standards. The metadata description for object “paper published in journal” along with needed controlled vocabularies were also defined and agreed upon at the national level.

By 1 March 2017, 30,276 digital objects were stored and described with rich metadata in repositories in DABAR. Figure 1. shows the number of digital objects stored in the repositories in DABAR by months (DABAR statistics, 2017).

In addition to the institutional repositories, through cooperation with the National and University Library in Zagreb, SRCE has set-up two national repositories:

- Croatian Digital Theses Repository at https://zir.nsk.hr
- Croatian Digital Dissertations Repository at https://dr.nsk.hr.

The impact of DABAR is recognized and visible at the national level through strong interest and involvement of research and higher education institutions (National and University Library, universities, colleges, libraries, institutes) resulting in a significant increase in the number of institutions that have decided to establish and maintain their digital repositories. Furthermore, the importance of publication of information in open access has gained momentum. On March 1st, the repositories in DABAR contained 11,744 digital objects available in open access.

During 2016, employees and students of institutions were involved in the process of storing digital objects through the implementation of self-archiving functionality. Eight Croatian universities have set-up their institutional repositories in DABAR. The team that worked on DABAR put a lot of effort in interoperability of DABAR with other repositories and services using the two basic technologies: REST API and OAI PMH.

5. ARHITECTURE OF DABAR’S INFRASTRUCTURE

DABAR’s repository system is based on Islandora[4], an open-source software framework. Islandora is designed to manage and discover digital assets and it has grown to be a reliable system for repository management. Main framework components are Fedora Commons, Apache SOLR and Drupal. Fedora Commons is another open-source project dealing with preserving and managing digital objects while offering exposure of stored resources through RESTful API. The framework uses well-known Apache SOLR for indexing Fedora content for faster metadata access using advanced and optimised search mechanisms. GSearch, as a part of the Fedora package, is used as a bridge for automatic synchronization between SOLR and Fedora content. Drupal is an open-source CMS providing Islandora users front-end for viewing, editing and storing digital objects in Fedora. Islandora’s built-in flexibility allows institutions to build large systems that can scale on demand and its modular architecture can be easily used for extending in desired directions.

DABAR ensures constant development and expansion while meeting a demanding functionality roadmap. Research and higher education institutions, repository managers and end users expected rich and accurate metadata and, at the same time, efficiency in storing and describing digital objects. To meet those expectations, it was necessary to rely on existing infrastructures and data sources (Figure 2). One of the first tasks while building DABAR was to enable user authentication through Croatian science and higher education identity federation AAI@EduHr[5] so that the users could use their existing institutional credentials and single sign-on functionality.

The support for depositing electronic theses in repositories in DABAR relies on Information System of Higher Education Institutions (ISVU). ISVU is a national information system which had been, by the

[4] https://islandora.ca/about

[5] http://www.aaiedu.hr/en

end of February 2017, used by 111 Croatian higher education institutions to administer data on teachers, assistants, syllabi, curricula, students enrollments, exams, tuitions, theses etc. In addition, ISVU exposes data through well-documented REST API. In the process of describing and storing theses in repositories, the metadata are fetched from ISVU. Other national registries (for example the Registry of study programs maintained by the Ministry of Science and Education) are used in the process of storing theses and dissertations. The fact that these sources were used for depositing digital objects in repositories and that metadata will be publicly available, *motivated and encouraged* institutions and the Ministry to increase the data quality and accuracy.

While building support for describing and storing papers published in journals to institutional repositories, the development team acknowledged the fact that there were already repositories in which these objects might be described and stored. The HRČAK[6] portal is a platform built for Croatian journal editors for publishing journals in Open Access. On 14 March 2017, it contained more than 155,000 papers available in full text which were described and stored by journal editors of more than 420 journals. To retrieve article metadata and URL of files in PDF format, DABAR uses HRČAK's OAI-PMH[7] interface. For the articles that have a DOI assigned by CrossRef, DABAR uses CrossRef API[8] to retrieve article metadata which was delivered to CrossRef in the process of assigning a DOI to the article. Similar connection is being built for retrieving metadata and PDF's from Croatian Scientific Bibliography (CROSBI) which stores scientific papers with more than 460,000 bibliographic records and more than 30,000 full-text papers available (Hrvatska znanstvena bibliografija, 2017). The plan is to implement metadata retrieval from PubMed Central. PubMed Central is a free full-text archive of biomedical and life sciences journal literature which exposes articles metadata through API[9].

A unique persistent identifier URN:NBN is assigned to each digital object stored in any repository in DABAR. The URN:NBN is assigned by URN:NBN service developed and maintained by the National and University Library in Zagreb.

Besides support for direct input via user interface, digital object can be stored in repositories in DABAR via the DABAR REST API. DABAR REST API was implemented because there were various external sources that already contained the fully described digital objects and had the need to transfer and store the objects in a repository in DABAR. One example of a system that is using DABAR REST API is institutional information system that already has theses stored but doesn't have all the dissemination features of a full-blown digital repository. Another use-case for DABAR REST API is an existing stand alone institutional repository that wants to migrate its content to the repository in DABAR.

An important role of digital repositories is to support dissemination. Besides the user interface, all repositories in DABAR have a built-in OAI-PMH which exposes structured metadata in two standard metadata formats: Dublin Core (DC)[10] and Metadata Object Description Schema (MODS)[11]. All OAI-PMH interfaces of repositories in DABAR are fully compliant with the OpenAIRE Guidelines for Literature Repository Managers 3.0[12] and are ready to be registered as a data provider on the OpenAIRE portal.

The landing pages of the digital objects all have Highwire Press and Dublin Core <meta> tags recommended by Google Scholar Inclusion guidelines for Webmasters[13]. This ensures that digital objects will be included in Google Scholar searches.

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[6] http://hrcak.srce.hr

[7] https://www.openarchives.org/pmh/

[8] https://github.com/Crossref/rest-api-doc/blob/master/rest_api.md

[9] https://www.ncbi.nlm.nih.gov/home/develop/api.shtml

[10] http://dublincore.org/documents/dces/

[11] http://www.loc.gov/standards/mods/

[12] https://guidelines.openaire.eu/en/latest/literature/index.html

[13] https://scholar.google.com/intl/en/scholar/inclusion.html#indexing

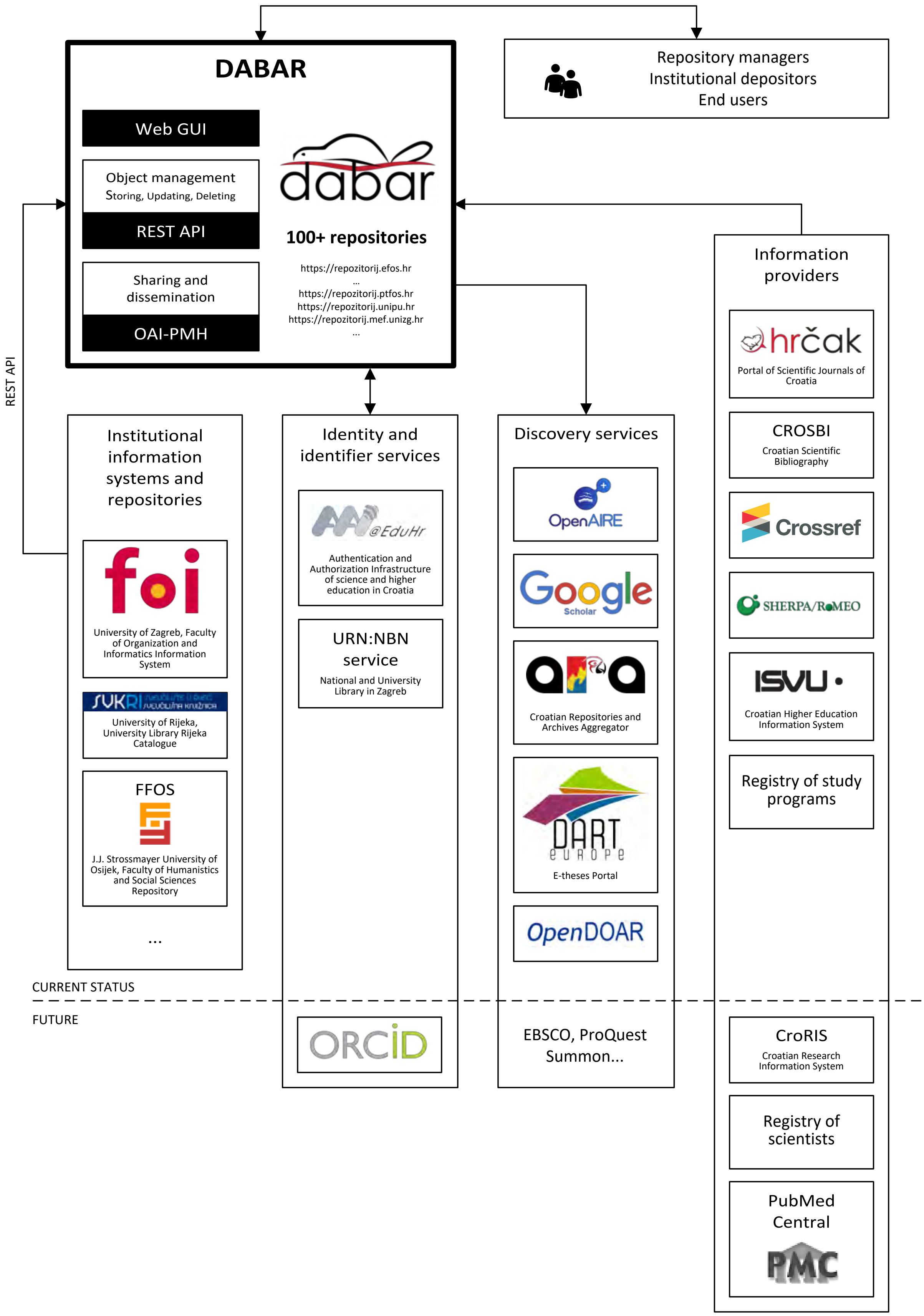

Figure 2. DABAR's integration with national and global e-infrastructure

DABAR's presence on OpenAIRE portal, Google Scholar and other discovery services drives a greater number of readers to repositories and its content and makes the repository content, authors and institutions more visible. Figure 2 ilustrates DABAR's integration with other national and global services.

DABAR's modular architecture is presented in Figure 3. Each of the servers has its unique function in the Islandora framework, extended with continuous integration (CI) server and servers that are mirroring production environment for development purposes. DABAR was built following Software as a Service (SaaS) delivery model in order to provide easy access to a fully featured platform for the institutions which are using it.

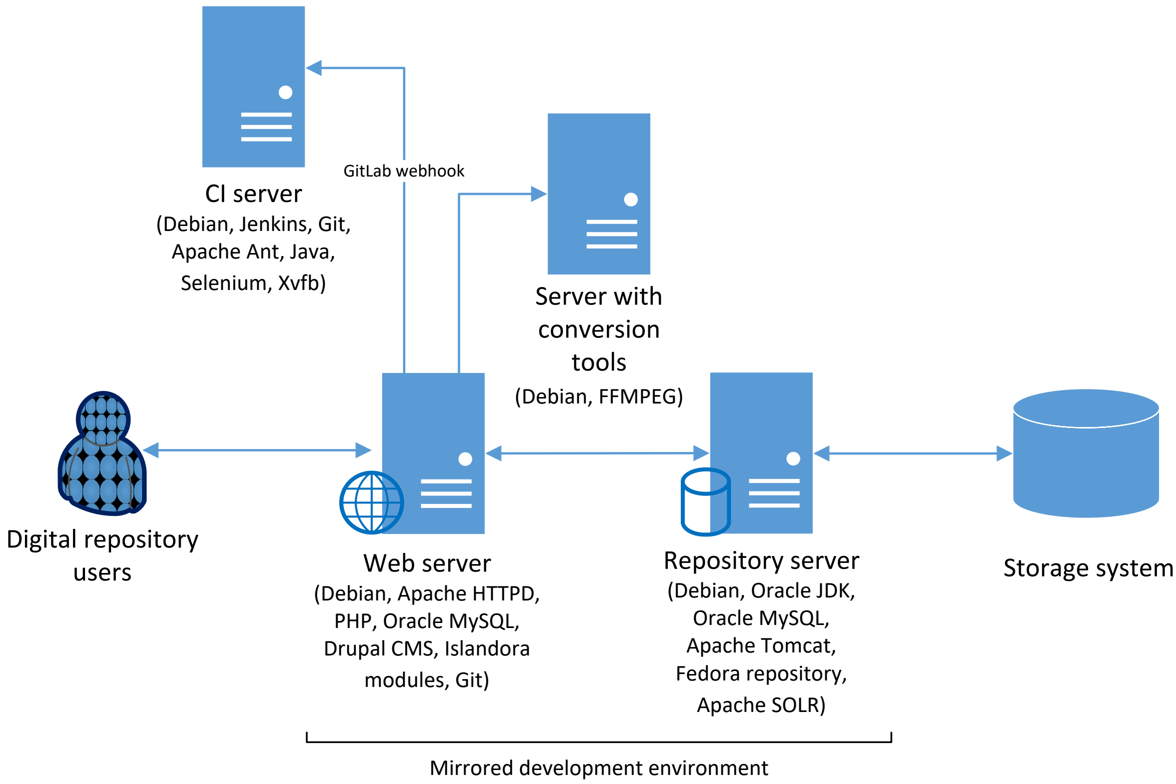

Figure 3. DABAR architecture

6. FURTHER DEVELOPMENTS

DABAR has brought together the research and higher education community providing them with a nationally accepted solution for preservation and dissemination of electronic theses and dissertations, articles published in scientific and professional journals. Still, that is just a good start in fulfilling the institutional needs. Next digital objects that will be introduced during 2017 are conference papers and presentations, book chapters, books and artistic works, including photographs and audio-visual objects. In 2017 we plan to start the work on research data management and educational content.

Given that only 40,8% (11,744 from 28,779) of all available objects in repositories in DABAR are published in open access, a big challenge for DABAR team and community is to promote open access further and support institutions in creating preconditions for publishing in open access.

Interoperability, in particular with national information systems in science and higher education stays in our focus.

7. CONCLUSION

109 digital repositories were established in DABAR's repository system by research and higher education institutions in Croatia. This proves that DABAR has been recognised as a reliable, secure and easy-to-use national infrastructure for the set-up and maintenance of interoperable and sustainable digital repositories. The model of centrally managed national infrastructure helps in reducing the costs of development and maintenance. It provides interoperability for all of its repositories with national and global e-infrastructures. This model is applicable outside the system of science and higher education, for example, in elementary and secondary education system as a repository of educational content or as a commercial platform for hosting digital repositories. It is also applicable in other countries or as an international solution that would meet the need of a specific community.

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Shaping The Digital Future of The Smart Campus: Learning from the Past to Innovate the Future

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Keywords
"internet of things", "internet of me", "smart campus"

EXTENDED ABSTRACT

The word "shaping" has particular interpretations in the fields of education and psychology. It is about using reinforcement in order to tune successive behaviours in the direction of the ultimate goal. Is building design, from concept to realization, not about "shaping"? Baker (2012) refers to "*the buildings that house this important task (public education) not only shape the way we teach, but provide icons and symbols for the values we hold commonly in society*". Here she is referring to how school buildings are developed, providing a history of this activity from the early 1900s; so "shaping" is not a contemporary phenomenon. Behaviours can be multifaceted; from those of influencers to those of implementers. Embryonic concepts as they are transformed into detailed plans are successively shaped and reshaped within the envelope of "requirements versus time and costs". The past, in the guise of experience, is frequently adopted as a powerful shaping influence however erstwhile limitations must be given balanced consideration if the past is to positively assist in innovating our future educational campuses. The "lead-lag" relationship between the needs of present and future learners, visionary academic leaders and their "real estate" counterparts is a significant consideration in innovative planning; one party may push the "educational considerations of the building concept and design" envelope to its limits whilst the other takes cognisance of physical space, time and cost, concentrating on contemporary automation solutions, occupancy levels and other forms of operational efficiencies. An optimum balance between these competing factors is what ultimately shapes their campus development outcome.

Building designs have evolved over the millennia so why should present and future developments be considered any more intelligent or smarter than their predecessors? Often the meaning and use of common words is transformed to convey modern concepts. "Smart" used to describe a campus or building is one such word. In an educational context, has the learning experience been enrichened as the design of educational establishments is influenced by progressive technological, social and political shifts? Is there a particular reason why the adjective "smart", or "intelligent" is more relevant in describing today's buildings, in comparison with say those of 50 years ago?

Successive technological developments have played their part in our internal environmental standards, whether associated with homes, factories, educational or other social spaces. Developments such as construction standards, materials design, lighting, acoustics, building services e.g. sanitation, electricity, telephony and digital networking, form part of a timeline of innovations that have impacted upon man-made spaces, and in turn, upon their use whether in terms of comfort, hygiene, efficiency or longevity and operationally. With a specific focus on education, research into teaching and learning practices sitting alongside cultural, social and political influences are interwoven into an environmental tapestry where the technological components play increasingly dominant parts.

It is the constructive harnessing of the interaction between technologies, especially information and communications technology (ICT) that produces contemporary spaces encompassing automation where the adjective "smart" or "intelligent" is adopted. Nuzzaci et al (2012) provide a comprehensive narrative on a particular interpretation of "smart" that focusses on the roles of ICT in creating "*university teaching-learning contexts in order to improve the quality of education and quality of life for individuals*". This is a specific, and valid, interpretation of "smart" yet ICT may also harness data streams from myriad sensors to enhance the concept. For example, the European

Commission describes smart buildings as "*buildings empowered by ICT in the context of merging ubiquitous computing and the Internet of Things (IoT): the generalisation in instrumenting buildings with sensors, actuators, micro-chips, micro- and nano-embedded systems will allow it to collect, filter and produce more and more information locally, to be further consolidated and managed globally according to business functions and services*." This view, however, implicitly refers to the human element, yet most buildings serve a purpose where the human role is paramount. Higher education buildings, and associated campus environs are a case in point so how can the human factor be incorporated within a description of a smart building? By considering the human element, the United States of America's Government Services Administration (2006) views a building's performance to include "*happier, more productive tenants. … that requires insights into the hearts and minds of the people inside. What a dashboard can really do is enable better decisions, inspire participation, spread knowledge and best practices, communicate at a human scale and propagate new norms in how we use our buildings*." Richichi (2010) cites several of the issues requiring consideration whether in new buildings or in refurbishment projects.

The Internet of Things (IoT) is another widely publicised technological concept; "a world of everything being internet enabled and networked"; a world of "smart" everything facilitated through the aggressive deployment of the Internet Protocol (IP), wireless networking and ever faster and broader networks. IoT is sufficiently mature to be taken seriously by stakeholders involved in built environments that are concurrently also learning environments. Ubiquitous low-cost trendy devices that are part of this IoT world are affordable and in the hands of an increasing sub-population of our tertiary communities. Innovating for the smart campuses must learn from past practices in teaching, learning and building design if we are to map out new routes for the realization of the IoT concept; flexibility being paramount.

We are at a crossroads of benefitting from a transformational paradigm shift in learning environments; the intersection of futures in technology supported learning environments and the futures in next generation smart campus construction. The notion of personalized IT, as conceptualized in the jargon "Internet of Me" is relevant to the present generation, in particular the extent to which "smart", "wearable", "mobile" technologies are the centerpiece of today's teenagers' lives. Conscious decisions must be made; do we invest in technologies that promote learning environments by empowering the student with "anytime anywhere" digital access to knowledge content or do we invest in smart physical environments that ubiquitously accommodate learning environments? Both concepts empower the student. Both need significant investments. Can there be a confluence of concepts, an utopia where symbiotic benefits appear from synergies of convergence of ideas, techniques and solutions? These are pertinent questions for a University seeking to fulfil the expectations of current and future generations.

The relevance of a smart campus concept is examined in terms of being a product of multiple parties (architects, community, engineers, government, industry, planners and policy makers) and of multiple inputs (human, technology and systems). Opportunities at the intersection of the smart campus built environment concept and smart objectives for the delivery and administration of tertiary learning and education within the environment are discussed. New ideas and concepts that could offer proof of concept use cases as well as novel projects are proposed. User-led innovation, as opposed to institution-led, underpins the successful implementation of smart environments. What innovations are being implemented and what others should follow? Existing projects are used to illustrate approaches to foresight and innovation; an approach whereby trusted expertise inspires others to innovate and where ideas become reality. The paper presents new ideas for design concepts challenging legacy ideas of 1990s architecture-led design to technology-led environments for 2020 and beyond.

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TOP-10 Insights - Trends in Higher Education

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Keywords

TOP-10, trends, HEI's

1. ABSTRACT

The nature of higher education institutions and their service models are changing due to the economic situation in Europe, but even more so due to the changes in the digital domain. Work in which future trends affecting HEI's are identified is carried out by many notable organizations; Educause, Gartner, the NMC Horizon project, Caudit and Ucisa, to name a few. They aptly produce lists from different viewpoints of trends affecting the HE sector, mainly focusing on IT. However, these have not as of yet been analyzed on a European level.

Through ERAI (Eunis Research and Analysis Initiative) we are working to provide a piece to the European puzzle. We believe it would be beneficial to not only identify what has been suggested, but to start a discussion on the impact of these trends on HEI's, and a dialogue on what – if realized – these trends mean to the institutions.

The work done so far is good grounds for discussion, and what we hope to do is to start a wider discourse of Higher Education trends in a European context. During the spring we will carry out a process in which we do a close reading of the reports and, as a result of this, produce a first draft of an aggregate by the time of the conference. We will fine tune the process throughout the spring, and by the time of the conference will also have a more in-depth description on the main goals and the future steps to take after the aggregate. At the Eunis conference we would not only outline the process of the trend work, but more importantly extend an invitation for professionals in the higher education sector to participate in this.

We recognize several different audiences to whom this work is of interest, for example student administration staff, support services, experts on pedagogy, digital education and learning, and experts on research administration. For the purposes of this work our aim is to involve and engage IT leaders from different countries to comment on the trends. Thus the conference would serve as a starting point and a forum for discussion and for building our own narrative on the trends identified in the field. Time permitting, in addition to the aggregate, we will also do some preliminary analysis of the NMC Horizon project, Caudit and Educause TOP-10 issues. After the conference, in the next stage, we hope to interview IT leaders and, building on this, produce further analysis on the trends.

A shared view of the trends might help the institutions to anticipate and to optimally adapt to the trends. We strive for a pan-country collaborative approach, as a wider base will enable us to form a European perspective and produce value within a European context. The aim for this work is to provide an outlook on what is to come; to convey one possible picture of what the future of the international higher education will hold. As the trends are ever evolving, our plan is to make this a continuous process, to compile an aggregate annually, as this would enable institutions to follow the changes in

the field.

Previously identified trends have suggested that some of the core tasks may be outsourced and acquired from organizations outside the institutions' traditional ecosystems. Cooperation within the institution and faculties, but even more importantly between the institutions, will make a greater success factor in a small market. Business intelligence thinking is inserting itself even more in HEI's, and academic and learning analytics will be utilized to a greater degree. There is also some indication that the core structure of the institutions is changing, affecting the roles of staff in various ways.

Our analysis hopes to focus discussion on the topics at hand on a European level; identifying key issues may help the institutions in finding a common ground when planning ahead, thinking anew their ecosystems, and in identifying possibilities for working together.

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EUNIS 2017: Laptop lending, with zero-effort?

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Keywords
BYOD, lending, license, virtualization, computer, PC, statistics, resource

Abstract

Currently we are still seeing a flood of hype to implement BYOD in different ways also in HiEd. This paper presents Metropolia's current plan for the future's flexible PC-classroom. This paper also presents the challenges that we are currently facing.

Do you really know how the computers of your organization are used? Are your PC-classrooms in wrong places at wrong time and also wrong size AND of course never with the needed software resources?

1. Introduction

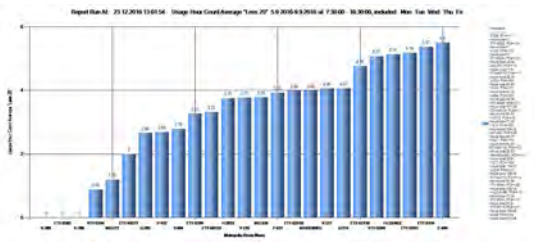
Metropolia's need to optimize its current resource usage still remains, as the Finnish financial climate hasn't changed from Eunis 2015 presentation. At the same time we are testing and looking for new ways to use the students' own devices for their studies. This change should not be driven only by IT-departments as it will also require changes in teaching. The outcome in the future will be sum up of multiple things.

We have to know where we are to make decisions for the environment. We have been collecting info about how our computers have really been used, and the data shows the challenges with too stationary environment. Walls limit us too much.

1. Current situation

We are currently building a new 6000 student campus and it is going to have only six PC-classrooms. Is the BYOD answer for that situation? We are not able to say how future will be in five years and that's why we have to have a plan for PlanB for situation where we are not able or allowed to use students own laptops in learning process.

When analyzing current usage and resource reservations, we are able to say that the real usage of computers is far too low. By looking only the timetables we are seeing the reality wrong way. We might have room's resource calendar full of teaching, but then the size of the group is not optimal as the usage of the computers is low. And also that, that we do have PC-classrooms, what we don't really use properly.



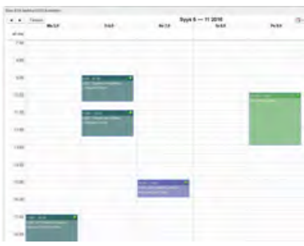


Figure1. Less25 period 1, study year 2016-2017
Figure2. Classroom P214 reservations period 1, study year 2016-2017

When talking with the teachers about the classrooms, they are saying that PCs are in wrong place, not free when needed, containing wrong software, broken etc. We also recognize that we have challenges in creating schedules for students which is also affecting resource reservations.

2. The future planB, automated unmanned lending machine

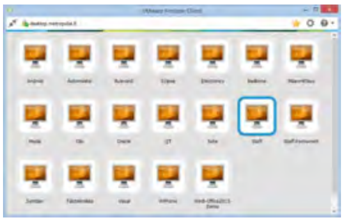
In the future we cannot be totally locked to fixed classroom. In our vision we have a PC classroom which has small amount (4-8) traditional PC's, lot's extension cords on the tables for own devices and automated laptop lending machines in lobby for those whose laptops are broken, stolen or forgotten to home. This is the best way to try ensure 100% usage for computers in the PC classroom.

In new campus we might have a situation where we need have 400 laptops for short term lending as those six PC-classrooms are not enough for 6000 students.

With automated lending machine we try to tackle multiple challenges.

1) Lending anything normally requires manpower, which means and raises expenses
2) Fixed size classrooms, normal fixed PC classroom is always wrong size for the group
3) Licensing issues, some programs we are not allowed or we cannot afford to provide to students own laptops AND there is no alternative program as freeware etc.
4) With this kind of machine we are able to provide PC classrooms where they are needed and when they are needed. By reading schedules before the new period starts, we could move certain amount of lending machines to optimal locations or floors where computers are needed
5) By integrating lending machines to our building (mobile) info system http://ihana.metropolia.fi we are able to tell easily to users where lendable laptops are or where to return borrowed laptop.

Other task is to provide same study environment to that borrowed laptop what students are using for their studies. We are currently using VMware View environment to do that. By providing centrally the environment, we try to minimize time used for fixing potential problems with those borrowed devices.



We are currently testing this kind of concept in our university https://wiki.metropolia.fi/x/l4GZBg and first impressions are really positive for this kind of service. Students are able to lend laptops when they need it. Technically laptops are running with Wioski locked down Windows10 LTSB system. The basic Windows Shell is replaced by a VBS script on the laptops. The script only launches VMware View client which is used to connect to Metropolia's VDI environment. When the user closes the client, user is automatically logged out. The laptops are domain joined, so we have a working SSO with VMware Client. The laptops also have a bundled Task Scheduler task, which shuts them down automatically when the laptop is plugged into a power cable. This also initiates a full laptop reset. The laptops report their battery usage percent to the lending machine every couple of minutes, thus we constantly have up to date information on the charge level of the laptops. This information is used to calculate how long the laptop needs to charge to reach the required minimum charge percentage for lending.

Our goal is to create 100% used PC classroom for the future.

3. AUTHORS' BIOGRAPHIES

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Lab4Act: Laboratories for Active Learning Spaces

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Keywords
Learning spaces, transitional spaces, active learning, informal learning, beacon technology.

1. SUMMARY

The Lab4Act project aims to investigate, develop and assess solutions for optimizing and modernizing the transitional spaces of academic school buildings in order to promote or enhance active and informal learning. This project follows the "E-Learning Cafés" project of the University of Porto that allowed the establishment of two dynamic learning spaces on the University campus, focus on promoting the integration of social and study activities, encouraging students to exchange ideas and knowledge, fostering interdisciplinary and innovation.

2. INTRODUCTION

The profound changes in the use of spaces in learning-related activities, especially in educational contexts, were boosted by several reasons including the advances in the understanding of the processes involved in learning, the digital technology revolution and its influence on various spheres of human daily life, and the emergence of the Google generation, or 'net gen' (Tapscott, 2008), to which the current students belong.

Although it is possible to identify a vigorous growth of bibliography dedicated to the study of educational spaces (namely in the reflection on the relation between the physical space and the teaching-learning processes) several authors suggest that knowledge about this subject is still insufficient to respond to the requirements that contemporary educational contexts demand, particularly in university education (Boys, 2010; Temple, 2007).

Today we recognize the importance of transitional spaces in educational buildings. Indeed, nowadays, learning-related activities transpose the limits of educational spaces and lecture times to take place in atriums, courtyards, corridors, bars, entrances and other meeting areas (Beckers, 2016; Oblinger, 2006; Vieira & Krüger, 2015).

Currently students are motivated to position themselves as the principal agents for the construction of their own knowledge and development of competences and qualifications. The students' autonomy and engagement with active and personal construction of learning are stimulating a transposition and extension of learning activities to spaces and times outside the classroom and lecture times (Jamieson, 2009; Oblinger,2006). Transitional spaces should therefore not be interpreted as mere links between classrooms, since they play a different role in the daily life of the schools: they take the place of choice for active and informal learning. Yet, for the most part, this set of spaces has not been conceived under this assumption, and therefore it is urgent to rethink and seek solutions to promote new forms of use and appropriation in learning related activities. Indeed, the design and materialization of buildings are linked to pedagogical foundations and curricula that will favour or inhibit educational practices, such as a 'spatialized' pedagogy (Monahan, 2000).

The Lab4Act project was born out of this recognition and seeks to investigate the relationship between non-teaching spaces and active and informal learning in order to propose new spatial solutions or adaptations to improve it.

To some extent this project follows on the "E-Learning Cafés" project of the University of Porto, which offered to students and academic staff of higher education two innovative spaces of study and social interaction, aiming to optimize the conditions for active and interdisciplinary learning (Ribeiro et al., 2013; Vieira et al., 2009). The “Asprela Polo” E-Learning Café, inaugurated in January 2008, achieved by the refurbishment of an existent building, was an important step towards achieving this goal and is at present an important generator of new educational, social and cultural dynamics in the academic community. The second space of this type, the E-Learning Café of the Botanical Garden, resulting also from the rehabilitation of an old house and inaugurated by the University of Porto in October 2015, is located in an area of the city of Porto with a great heritage value, not only because of the botanical importance of its rare species, but also for being a representative example of the XVIII century farms and cottages, and, as well, for being a referential place of Sophia de Mello Breyner Andresen life and work (a Portuguese renowned writer and poetess). This space, like the previous one, is supported by a pool of information and communication technology resources and services and has quickly become a reference point for the academic community.

The Lab4Act, an exploratory project, proposes to study the links between the physical spaces and the resources they offer on the one hand, and the social relations, interactions and learning activities prevailing therein, on the other hand, to identity and reveal the potential of the spatial configuration to favour active and informal learning.

The e-Learning cafes and other common spaces of the fifteen schools of the University of Porto will be the work base of this project to propose the creation of what we call laboratories for active learning spaces (Lab4Act).

It is expected that this project can contribute to the creation of new Knowledge that may support and incentive future studies and interventions in higher education spaces.

3. OBJECTIVES

The overall objective of the project Lab4Act is to contribute to the improvement of learning in higher education through the modernization and transformation of transitional and communication spaces in university buildings to stimulate active and informal learning.

In a first phase, Lab4Act aims to analyse spatial contexts by looking for attributes that influence the choice of out-of-class spaces for activities related to active and informal learning. In a second phase, the goal is to develop, test and evaluate intervention solutions in these spaces to improve their adaptability to the new learning requirements. The general idea is to leverage each Lab4Act space for active and learning in non-teaching times through low-cost interventions which, in a first phase, will provide equipment, furniture and digital artefacts to foster active, cooperative and informal education.

4. METHODS

Bluetooth Low Energy (BLE) beacon technology will allow to monitor the dwell time of the users in the spaces, the displacement of the objects that exist according to the needs of the users, the time of usage of the available physical resources, the interaction between pairs, type of activity, among other indicators so as to be able to apprehend effects of the spatial context on students' behaviour. In other words, it will enable making meaning through relations between users, objects and spaces.

It is a low cost technology that will allow jointly with an APP to be developed within the scope of the project to map the use of the physical spaces and resources available in the environments that are being studied.

Through a comparative study on E-Learning Café and some schools of University of Porto, namely it’s Faculty of Architecture (FAUP), this research purpose to investigate the interplay between space, interaction and learning activities in higher education within exterior and interior interfacing areas in terms of halls, yard, lawn, corridors etc.

The research will use a multi-layered approach, combining quantitative and qualitative data collection and analysis, with semi-structured interviews, space syntax analysis and patterns of use observation on exterior and interior interfacing areas using BLE beacon technology.

5. DISCUSSION

Currently the project is in a phase of seeking funding to be implemented at the University of Porto. In this communication we will discuss the increasing importance of non-teaching spaces in higher education environments and the use of beacon technology for the improvement of these spaces in order to promote active and informal learning activities. Additionally we will also present the results of a preliminary case study at FAUP which allowed the identification of spatial features that promote face-to-face encounters and social interactions leading to informal learning activities, like reflective conversations, collaborative work in project based learning and creativity problem solving in communities of practice.

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She is author or co-author of more than 70 publications and responsible of several financed projects. She headed several University of Porto projects, in particular the information system (SIGARRA), the institutional repository, the grid project and the e-learning cafés project.

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Enabling Paperless Workflows through Digital Signatures

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Keywords
Paperless workflows, Qualified Electronic Signatures, Digital transformation

1. ABSTRACT

Paperless workflows are essential to the shaping of the Digital Future of Universities. Although academic and administrative management software eliminates the need for paper in many processes, there are still many others that require paper support, most often documents that require handwritten signatures, such as registration and degree certificates. That yields extra unnecessary steps for both parties involved and consumes additional resources, especially when such signatures need to be validated. With digital transformation in sight, in this paper we describe SmartSigner, a technological solution for digital signature of electronic documents, ready to be integrated with any academic management software. The solution is based on Qualified Electronic Signatures using smart cards which, for public institutions in Portugal, are created and maintained by a governmental office. The solution also aims to improve and simplify inter-university contract celebration, like for example, learning agreements in student-exchange programmes.

2. INTRODUCTION

Nowadays, many organizations still rely on paper to execute their workflows, which seems rather archaic, particularly considering the central role that digital technologies have taken in our daily lives. Since most of the information present in these workflows can be easily transformed from paper to a digital resource, most organizations, including Higher Education Institutions (HEIs), have been conducting significant efforts to adopt paperless practices. Indeed, digital transformation is becoming a common buzzword in organizations across the globe, as information technologies are increasingly perceived as the key enabler for achieving the, much sought-after, operational efficiency. The full implementation of a paperless information management systems presents various benefits:

- improved business efficiency, since less time is wasted in non-essential tasks;
- higher security on document legal validation;
- better process consistency;
- easier inter-organizational interaction;
- environmentally friendly;
- saves organizational resources (money, archive space, staff time, etc);
- easier storage and accessibility.

However, sometimes direct digitization is not possible, as in the case of physically signed documents. A physically signed or stamped paper document has no legal or authenticity guarantees after being digitized, rendering it useless. Therefore, a direct digitization of such documents is not viable since it is trivial for an attacker or ill-intentioned individual to virtually add the image of a signature to a document.

By employing digital signature mechanisms in official documents, HEIs can expedite the signing process and centralize signature verification. The process of signature or authenticity verification in physical documents can often be cumbersome, hence digital signatures increase the performance of the overall process by reducing the time required to validate the signature and authenticity of the document. Nevertheless, many organizations are still only able to deal with physical documents, and when a digitally signed document is printed its verifiability features are lost. This is a relevant issue, which will be also addressed in this paper, since official documents produced by HEIs will, often, need to be processed by external organizations (for example, by public transportation companies, to enable students to benefit from reduced fares).

To tackle the problem of conversion from signed or stamped paper documents to digitally signed electronic documents one needs to understand the purpose of signatures. Why are signatures used? Better yet, why are signatures required? The traditional function of ink signatures is to provide evidence of the provenance of a document (identity) and the intention (will) of an individual with regard to that document. An electronic solution to substitute the traditional method of handwritten signatures and stamps must provide the same guarantees: to give evidence of provenance, the new signatures must be something that only the signing entity or individual could generate; to prove informed consent, the solution must allow the document to be properly reviewed and analyzed, and may even only enable the generation of a signature if the document was actually open and properly reviewed, for example.

2.1. Digital Signatures

Digital signatures are based on asymmetric cryptography, also known as public key encryption, where two different keys but related to each other are generated (R.L. Rivest, A. Shamir, and L. Adleman, 1977). While the public key must be publicized, the private key must be kept secret. When a signer digitally signs a document, the signature is created using the signer's private key. The resulting encrypted data is the digital signature. The signature is also annotated with the time at which it took place. If the document changes after signing, the digital signature is invalidated.

To validate a signature the public key of the signing entity or individual must be known. Since false information can become a problem, a Public Key Infrastructure (PKI) was created stipulating a set of roles, policies and procedures for digital certificate management. A digital certificate is an electronic document used to prove ownership of the public key. A Certificate Authority (CA), which is an entity that issues certificates, uses his own private key to sign those certificates, such that its public key can be validated by the requester. The function of the CA is to create the certificates for all the parties involved, except those above it in the chain of trust. These certificates are in the form of X.509 certificates (Cooper, et al, 2008). Digital certificates are verified using a chain of trust. The trust anchor for the digital certificate is the root certificate authority (Microsoft website, 2008). For the validation of the certificate to succeed, if the signature's associated certificate contains in its chain of trust a CA already recognized by the operating system (such as VeriSign), no additional steps are required. Otherwise, the root CA can be manually added to the system.

2.2. Legislation

Since digital signatures are an implementation of advanced electronic signatures (Dhakar, R. S., 2012). According to EU regulation No 910/2014, an advanced electronic signature is an electronic signature which meets the following requirements: (a) it is uniquely linked to the signatory; (b) it is capable of identifying the signatory; (c) it is created using electronic signature creation data that the signatory can, with a high level of confidence, use under his sole control; and (d) it is linked to the data signed therewith in such a way that any subsequent change in the data is detectable, all of the requirements already achieved with digital signatures such as PAdES (ETSI, 2009). Qualified electronic signatures are capably of identifying the signatory remotely, using electronic identification means, for which prior to the issuance of the qualified certificate, a physical presence of the natural person or of an authorised representative of the legal person was ensured; if a body governed by public law serves as the CA to the certificates that will be used by the signers, we can elevate the signatures to qualified. ‘Electronic time stamp’ means data in electronic form which binds other data in electronic form to a particular time establishing evidence that the latter data existed at that time. This regulation states that an electronic signature which contains a qualified time stamp (i.e. distributed by the appropriate government entity), hold the same legal value as a handwritten signature would have.

2.3. Paper Outline

In this paper we will discuss the digital transformation of the student registration process in our school, as a case study for illustrating the application of qualified digital signatures as an enabling technology for migrating to paperless workflows. Section 3 will provide a brief introduction to the old, paper-based, student registration process, which still required paper documents and traditional ink signatures. Section 4 will detail our new approach, relying on qualified digital signatures, which was the drive for the development of our own SmartSigner system. Section 5 will explain the most relevant implementation details and related technologies of the SmartSigner system. Finally, Section 6 will discuss the impact of this new approach in our school, as well as the benefits that other HEIs could obtain by adopting similar solutions, namely in student-exchange programmes, exemplifying the difficulties that could be eased, based on students' testimonies.

3. CASE STUDY

Instituto Superior Técnico (IST) is the leading engineering school in Portugal and one of the leading engineering schools in Europe, with more than 11,000 enrolled students and more than 800 faculty and researchers. IST’s academic and administrative management software, FenixEdu Academic[1], has been developed in-house for more than 12 years and is the result of the school's efforts to eliminate the need for paper and more efficiently maintain academic information such as: student, teacher and staff information, class schedules, allocated classrooms, exams schedules, etc. Aligned with this long-term effort, we decided to focus on improving an important, yet still inefficient, workflow: the student registration process.

The student registration process starts after the National Contest for Admissions to Higher Education is completed. The admission list is provided by DGES (the governmental office responsible for the admissions to all public universities) to all national HEIs. IST imports the list of admitted students into FenixEdu Academic system, classifying these students as new candidates and creating new accounts (username/password pairs) for them, which will subsequently enable them to access all computer resources in the school.

On the day of registration, candidates must physically come to the school, where a sheet containing the account info is handed to them, with their username and password, which is used to access FenixEdu Academic system. The candidate must then complete its registration process, at the beginning of which he is invited to introduce his Citizen Card[2], enabling the system to collect the candidate’s personal information stored in the card (e.g. ID number, photo, name, address, etc). If no Citizen Card is provided, the information that would otherwise be automatically collected must be manually introduced by the candidate. The registration process proceeds and the candidate is then required to fill several additional online forms. After that, the candidate registration is processed by the FenixEdu Academic system, and he effectively becomes a student of IST. The system then issues an identification sheet, containing all the student’s relevant information, that must be signed by the student after he checks that all the information therein is correct.

In order to complete the registration process, some sheets need to be printed:

- the student's' schedule;
- the tutor info;
- the tuition payment info, which consists of an ATM reference and the values in debt;

[1] http://fenixedu.org
[2] https://www.autenticacao.gov.pt/o-cartao-de-cidadao

- eight registration certificates that must contain an embossed stamp and must be signed by a member of the staff of the academic office of IST;
- form required by banks, to be filled and signed by the student.

Apart from the need to print all these documents, some need to be ink signed and stamped and physically delivered to the student: a process that overall is inefficient and expensive.

Outside the campus, many organizations also require a signed version of a registration certificate document. Some examples are the public transportation services (to offer reduced fares to students), and health insurance companies. If the registration certificates received by the student are not enough, the student may need to request additional ones. These new ones need to be printed as well, ink signed and stamped by someone in the academic office.

4. THE NEW APPROACH

The proposed approach tackles resource waste in the student registration process, while eliminating the need for paper. The solution also provides extension mechanisms to facilitate the integration with other different workflows. All the printed sheets that do not require a signature can be easily removed from the process by making use of the FenixEdu Academic system, e-mail or even sms, leaving only the documents requiring signatures and stamps addressed. To achieve that, we have defined a model that replicates the system's entities involved in the process. This model is generic enough to enable its use in other workflow processes that require signatures. The solution is based on the new SmartSigner system.

In the case study presented, the registration certificate must be ink signed by a member of IST with a proper authority, who asserts that the student is indeed a student of the school. SmartSigner allows staff members with such authority to digitally sign the registration certificate document.

A signed document is the result of three conditions: (1) the existence of a document to be signed, (2) an authority with the responsibility of signing the document, and (3) a mechanism to generate the signature. Completing the analogy, the paper document will be a computer file, the authority will be a user with authorization to sign that document, and the mechanism will be a token holder, in this case a smart card. A smart card holds both the public and private keys, and has enough processing power to generate signatures within the card, preventing exposure of the private key.

After generating a digital document to be signed, the originating system (the FenixEdu Academic in this case) will deposit the document in the proper queue of the SmartSigner system. The SmartSigner system segregates the documents to be signed by queues. The documents on each queue can only be signed by a predefined group of users, which should be the ones legally authorized to sign the kind of documents that will be deposited in the queue. Additionally, each user has his own private queue.

In the SmartSigner system, the users can have two roles:

- system users, that will upload, review, sign, refuse or download documents;
- administrators, that manage the system's state, by adding users and token holders (cards and certificates), creating/removing/editing queues and managing permissions.

A simplified class diagram UML that explains the entities underlying the SmartSigner system is presented in Figure 1.

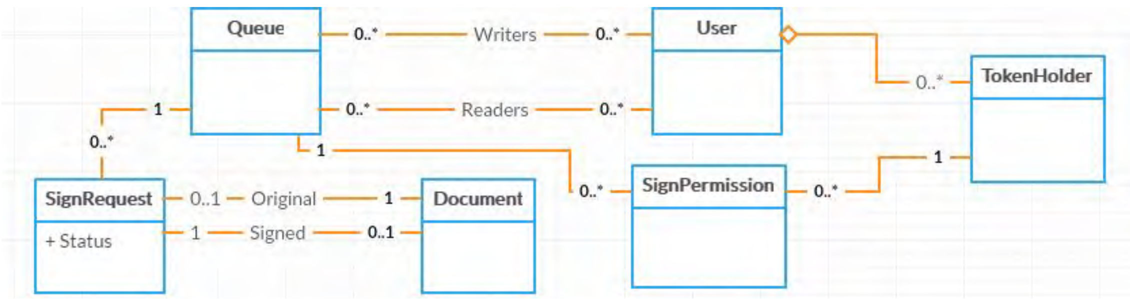

Figure 1. Simplified UML class diagram of entities underlying the SmartSigner system.

The only missing component is the one that allows for the actual signature generation process. In the paper-based process, a person hand-writes his signature; in the SmartSigner system, the application communicates with the user's smart card via a terminal (card reader), in order to successfully complete a valid signature.

4.1. Smart Card Emission

One of the possible smart cards that can be used for signing documents with SmartSigner is the Citizen Card, which can be legally used for that function. However, in our case and many other situations, the authority responsible for signing is a person who holds a specific office function (position) in the school. This represents a problem for an external entity that needs to verify or validate a signature. The problem lies in the difficulty to correlate the person with its office function: such information may not be publicly accessible. In addition, the person may no longer hold that function at the time of verification, which makes it even more difficult because the third party entity needs to discover whether the function at the time of signature was in fact correct. Finally, not all system users own a citizen card (e.g. faculty from a foreign country).

The HEIs in Portugal must follow government regulations, and, in our concrete case, since IST is a public school, its employees are also public workers. Therefore, delegating the responsibility of stating which employee has which office function to a governmental entity seems intuitive and practical. The creation of smart cards containing that information conducted by CEGER, the government organization responsible for certification. CEGER produces smart cards for some employees of IST, with certificates created and managed by SCEE, a hierarchy of trust that handles the electronic security of the government and strong authentication of Public Administration organisms to the citizens. It is imperative that the X.509 certificate contains information about the person that the smart card is being assigned to, and the position of that employee in the organization. On X.509v1, this data could not be properly represented, but X.509v3, an extension of the certificate, contains a field to hold the Subject Alternate Names. Since simply stating the office function of the card owner has no legal value, given that there is no backed legislation (and these signatures must hold the same legal value as the traditional ink signature), an OID was created with that purpose (2.16.620.1.1.1.2.2.0.2.1), holding legal value. The aspects and purposes of how and when the certificates contained in these smart cards can be used are explained in an official document issued by CEGER, entitled Declaration of Practices of Certification (ECCE, 2016). With the registered OID 2.16.620.1.1.1.2.3.1.2 and publicly available, containing the guidelines that developers and consultants must follow to properly implement a system that correctly and legitimately uses the issued cards.

4.2. Certifier

Previously, we stated that the migration from a digital version of the signed document to a physical one was not trivial. The adoption of paperless workflows has been slow, and most often only within the organizations. While many organizations already accept incoming (external) documents through e-mail, website interfaces or web services, this is still not the norm, at least in Portugal. Therefore, we had to address the problem of communicating digitally signed documents with organizations that would not accept them in digital form.

After there is a signing request that completed successfully, the digitally signed document is stored in FenixEdu Academic and can be referenced through an identifier. In order to enable easy access to the digital document for organizations without the ability to process and store it in digital format, we produce a paper version, which has an extra front page, which contains the complete URL of the original digital version, and a QRCode to quickly enable access to that same URL. As mentioned, a digitally signed paper in its printed format has no authenticity or provenance value, so the document to be printed must contain the information necessary to access its digital counterpart, which is typically done by generating a link (the document must be made available by the university). Since that requires manual introduction of random characters, to improve efficiency and usability, a QRCode is generated by the FenixEdu system and translates to the link where the document is stored. The signature receiver now has two options for verification of the signature's validity: either by manually introducing the link in a browser, or by scanning the QRCode using a regular smartphone or webcam.

4.3. Improved Workflow

In the previously stated requirements, all sheets of paper printed in the registration process need to be replaced by paperless alternatives. When a student accesses the FenixEdu Academic system using the account information received during the registration, if the student currently has any debts, those are shown right after the authentication step, remaining available on the system along with payment information. This information effectively replaces the sheet containing debt and payment information in the old workflow. Additionally, the schedule is already available on the system; the tutor name and contact information is sent to the student via an SMS; and the information required by the banks is provided automatically via web services if, during the registration process, the student authorizes his information to be electronically shared with that organization (a checkbox in one of the online form he is required to fill).

The academic record information sheet, containing personal information about the student, which originally needed to be printed and signed by the student, is now replaced by a PDF that is hand-signed electronically by the student using a special pen and an android tablet running an application also created by FenixEdu, that simply shows the previously mentioned information and collects the student's signature. Since this document is only used internally to prove that the student agreed with the provided and collected information, a hand-signed signature is sufficient be validated by an academic office clerk that is physically present at the time of signing.

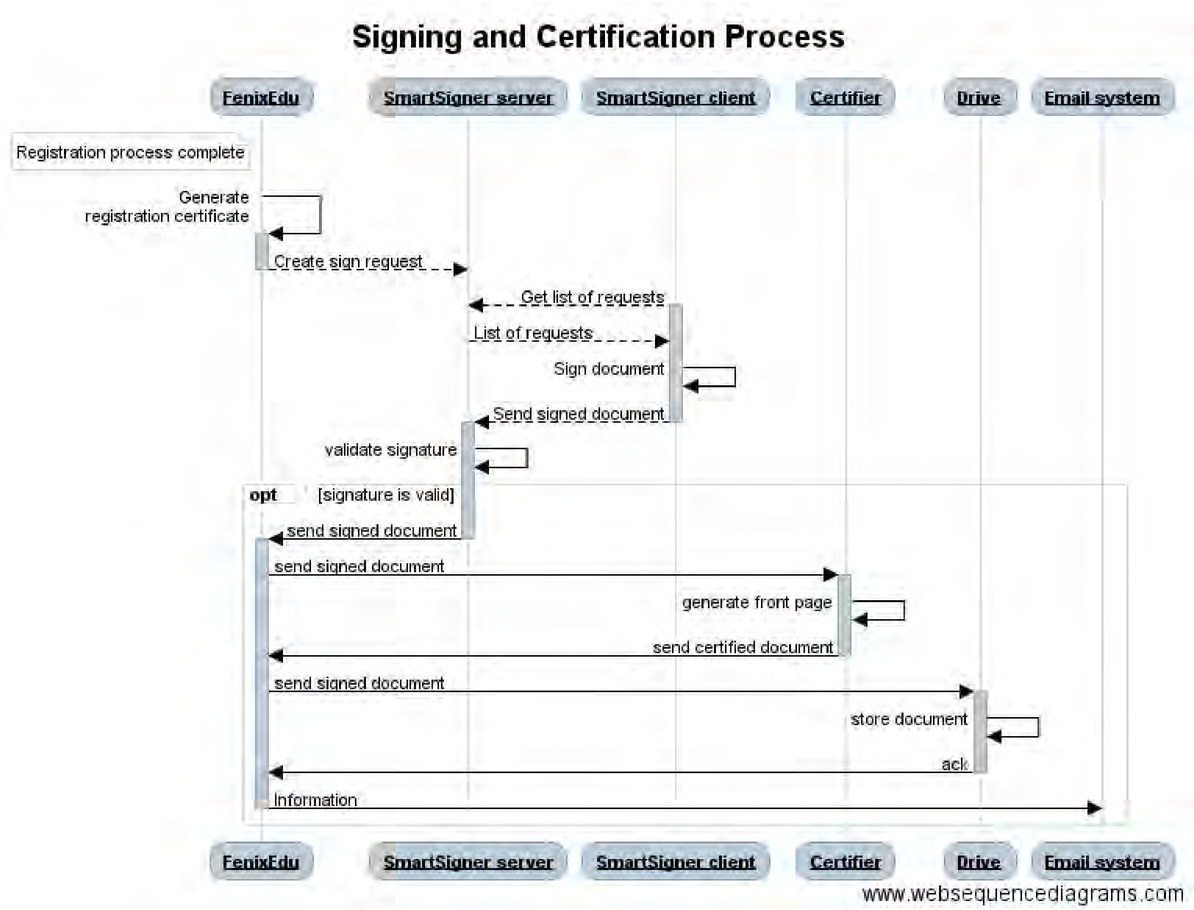

Figure 2. Signing and certification process.

Upon the creation of the student in the FenixEdu Academic system, a certificate in the form of a PDF file is automatically generated and added to a SmartSigner queue. This enables the users (academic office staff) allocated to that queue to sign the document using the SmartSigner client application. The document is then transmitted to the component server and validated by it, and then sent to FenixEdu Academic, system again that routes the signed document to the certifier. The certifier validates if the signature is legitimate, and stores it for later retrieval by entities requesting proof of validity. The certifier would ideally be managed by a governmental organization that stores the signed document, in order to verify that the paper version of the signed document points to a valid signature. After all steps are successfully executed, the document is stored in the student's document repository, so that he can access it whenever needed. Previously, additional certificates would be requested in FenixEdu Academic, and when ready (days later) the student would receive a notification pick them up in the academic office. Now, the student automatically receives the signed version in his e-mail inbox, and can always access it also on his document repository at any time without needing to request it formally. Figure 2 shows the signing and certification process after the registration process is complete.

5. IMPLEMENTATION

5.1. Components

SmartSigner architecture is mainly composed of three components:

- **The client (signer)** – This component is a standalone Java application using the JavaFX[3] graphics package for the interface design. This component is responsible for generating document signatures. It communicates with the smart card via the terminals (card readers) to execute the cryptographic algorithms necessary to generate a valid signature. Users authenticate themselves with a registered card; this client can also be used by administrators to extract the public key certificates of the smart cards and ease card registration;

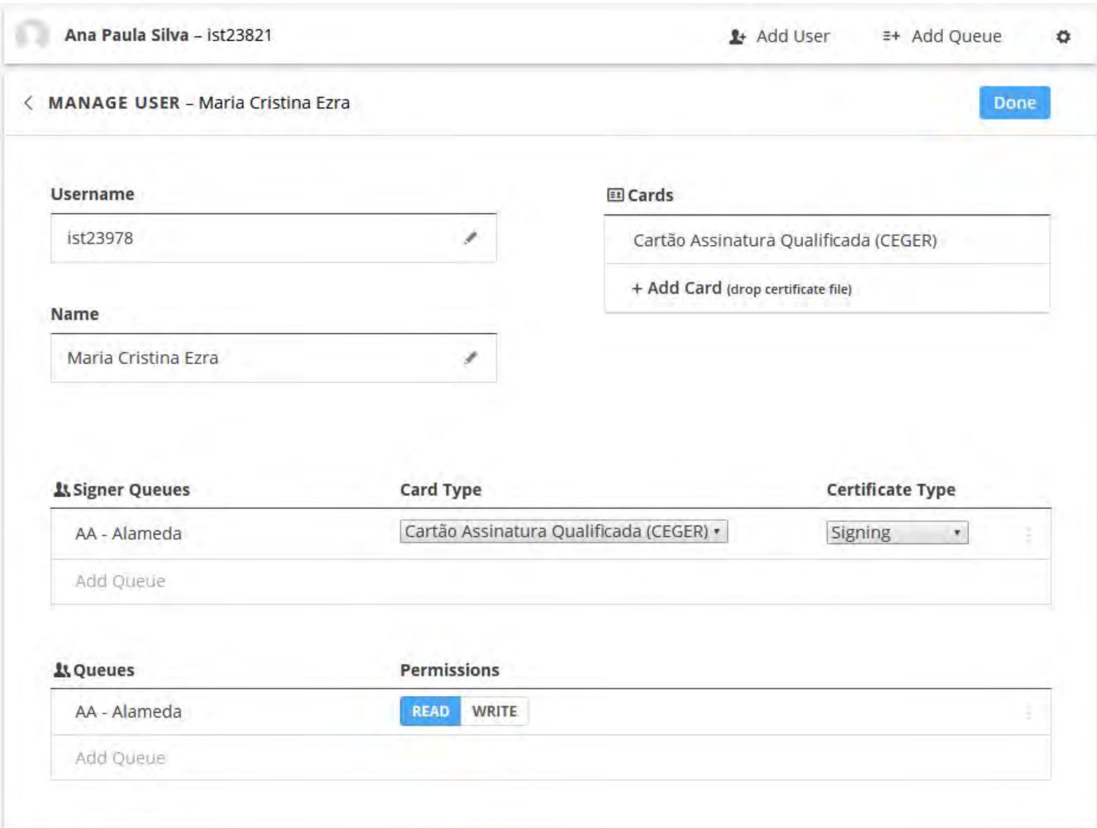

Figure 3 - Manage User interface

[3] http://docs.oracle.com/javafx/2/overview/jfxpub-overview.htm

- **The server (repository)** – Responsible for maintaining the state of the application (users, token holders, queues, etc.), essential to the functioning of SmartSigner, and the actual documents, so that they can be signed or downloaded. Within the signing workflow, the server both validates if the signature matches the signer certificate, and if the signature is in fact valid. The repository where documents are stored may be logically different from the where the server is lodged, but it is the server's job to act as a proxy between the SmartSigner's modules and the repositories;

- **The back-office (management)** - All system operations, such as managing users, queues, token holders, and permissions are done via the back-office component. The access to this module requires authentication but cards are not used given that the system's administrator may even not have a card; any form of secure authentication is sufficient. In SmartSigner, a simple combination of username and password is used, in our case, a Single-Sign On (SSO) strategy using JasigCAS[4]. Figure 3 shows the interface "Manage User", where users are edited, token holders are added or permissions are managed.

5.2. Technologies used

The client is implemented in Java, and uses two deployment facets: it can be launched via an executable jar file, or via JNLP which enables an application to securely be launched on a client desktop using resources that are hosted on a certified remote web server.These libraries include: iText (version 2.1.7 on a GPL) to generate and read PDF documents; the BouncyCastle library of security algorithms; and smart card vendor proprietary libraries that enable SmartSigner to communicate with the smart card.

The server-side of SmartSigner uses the Spring framework to handle business logic, and persists data through JPA/Hibernate. The server provides a RESTful API that is consumed by both back-office client, and Signer application client. The back-office client is a web-app implemented with AngularJS, HTML, authenticating users with a JasigCAS SSO strategy. Nevertheless, the authentication process can be easily integrated with other authentication providers since the back-office applications relies on an Authorization HTTP Header that provides a Bearer containing a Json Web Token (JWT)[5].

The extensibility of the client application is achieved through the indulgence of object-oriented paradigm and design patterns, which also facilitates development and maintenance. Since the system used may have connected more than one terminal (card reader), the SmartSigner client only allows one to be selected at a time to prevent ambiguity and user mistakes.

6. CONCLUSIONS AND FUTURE WORK

This paper discussed the digital transformation of the student registration process in our school, as a case study for illustrating the application of qualified digital signatures as an enabling technology for migrating to paperless workflows. In this context we also presented the SmartSigner system, a distributed system for digitally signing documents, which was developed within the school to address the requirement imposed by the new paperless workflow of the student registration process.

The implementation of this system exceeded expectations: previously, during the student registration process, the staff of the academic office had to spend 3 to 4 minutes to print, hand sign and deliver the required documents to each student to complete the process. Now, all these steps are automatic, except the for the signing step, where the staff only needs to have the SmartSigner client application open, select the correct queue and, with the proper card introduced, select the respective document and click sign. The signing process may take as little as 1 second. Nevertheless, this process can be done in batch mode, meaning that time can be reduced in manual actions such as selecting the document and clicking sign. This year, where 19 sheets of paper would be necessary per student (number varies because of mandatory bank forms), 8 of them would require a signature and a stamp, and 3 of them would need the student's signature. Since IST had 1,714 new registrations, 32,566 sheets of paper were saved from printing. From those, 13,712 (8 copies for

[4] https://apereo.github.io/cas

[5] https://jwt.io/

each one of the 1,714 students) of them would be registration certificates that would need to be hand signed by IST academic staff. Instead, 1,714 documents were signed digitally (no need for copies) using the smart cards generated for that purpose. Since this system is in production, a total of 11,437 registration certificates (also emitted for old students) were signed using SmartSigner, as Figure 4 displays. Obtaining each one of these registration certificates now does not require the cumbersome process of requesting, printing, ink signing, stamping, and delivering, which also alleviates the academic office from receiving and handling both the requests and deliveries. For future work, we estimate that the implementation of digital signatures on other processes like mark sheets can help save from printing 2,800 sheets of paper per semester, not to mention huge amounts of manual work, which is always more difficult to measure.

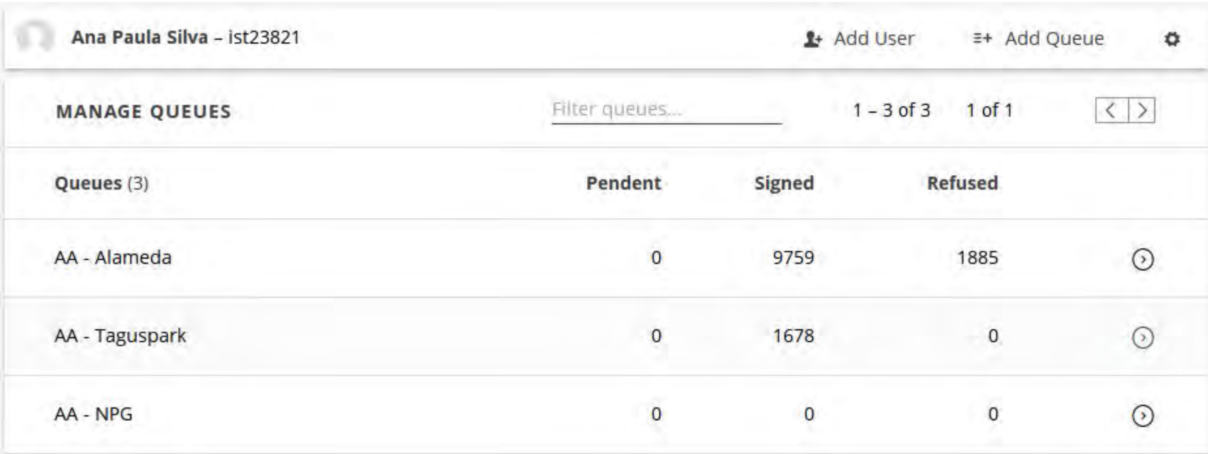

Figure 4 - Manage queues interface showing actual numbers

The next step is therefore to remove paper and its required ink signatures in all other processes that still exist. The mark sheets must be signed by the professor in charge of each course to become official. These signatures can either use the citizen card of the professor, or another card also generated by CEGER or other valid certificate authority. We hope to motivate other HEIs in pursuing paperless workflows, to handle their processes more efficiently and better focus on the education process rather than its administrative aspects.

Some organizations, especially public ones, showed some reluctance in accepting advanced electronic signatures, despite being legally obligated to do so, due to the internal process requiring a paper trace. The document generated by FenixEdu and explained in section 4.3 filled this gap. The students also showed difficulty understanding which document they should deliver, as we had reports of students simply printing the digitally signed document that was then wrongly accepted by the receiver as a valid signed document (which may be somewhat justified because the signed version contained an image with a signature appearance and an ok sign if the signature was validated, making us considering whether that should be removed), demonstrating that there is still some disinformation regarding electronic signatures. The organizations that only accepted the digital format or the physical paper but validated the signature using the Certifier had no problems checking if the signature was indeed valid using the predominantly operating system (OS) Windows, since there is an update on this OS that downloads the EU members CA's, allowing for on-the-spot signature validation using Adobe Acrobat Reader. There is a guide being written explaining the process of validation which will be made available in the official Tecnico's website so that the organizations can consult and hopefully avoid these issues.

Nowadays, students enrolled in student exchange-programmes such as Erasmus have to request a learning agreement, which must be signed by the Erasmus Coordinator at IST. That document must accompany the traveling student,until he can deliver it at the university where he will be studying. This learning agreement may be lost during transportation, therefore IST must keep a copy properly archived and identified; there are also reports from students whose agreements were updated during the programme, which led to the cycle being repeated. All this could be avoided with digital signatures: the student could send the signed agreement beforehand, to enable the proper verifications to be done. Going paperless is vital to the digital future of our higher education.

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