Automated Feedback: An AI-powered Tool to Scale Micro-level Feedback for Better Academic Writing

Ziwei Huang[1] and Wilco te Winkel[2]
[1]FeedbackFruits, the Netherlands
[2]Erasmus University Rotterdam, the Netherlands
jo@feedbackfruits.com, wilco.tewinkel@eur.nl

Abstract

Reviewing written work - whether between peers or from teacher to learner - can be an arduous process, exponentially more so within larger student cohorts. With that large potential time-sink, even less time is available for teaching. In addition, the majority of instructors' time is focused on correcting spelling, grammar, style, and semantics, rather than content and argumentation. These are 'micro-level' or 'lower-order' concerns: the writing aspects unrelated to argumentation or reasoning such as grammar, spelling, or reference. Focusing on these would divert teachers from providing feedback on 'higher-order' writing aspects: argumentation, reasoning, style and flow. This then increases teachers' workload while reducing the feedback quality delivered to students.

In order to address this issue, FeedbackFruits – an educational technology provider for higher education – collaborated with Erasmus University Rotterdam, Rotterdam University of Applied Sciences, and Deakin University to develop an AI-powered academic writing tool, Automated Feedback. This tool provides instant formative feedback for students on their lower-order concerns (such as correct references and grammar) to iteratively improve their writing product before handing in the final version. That is, teachers set up feedback criteria for students' assignments covering elements such as structure and content, academic language, citations and references, tables and figures within the tool. To fit into teachers' existing workflow, the tool integrates with different learning management systems (LMSs) including Canvas, Brightspace, Moodle, and Blackboard. Based on the teacher-configured rubric of feedback criteria, Automated Feedback analyzes the assignment and provides actionable feedback for students, thus helping them develop their academic writing skills, while reducing the reviewing workload of the teacher.

1. Background

Developing mastery of academic writing is vital to students' success, both at schools and in their future professional life. Academic writing is not only an essential professional skill, but also a life skill which sharpens students' learning, communication, and creativity. Hence, academic writing has remained one of the top skills to be included in curriculum planning of institutions. However, learning to write in accordance with academic principles is not simple, and teaching students to develop good academic writing skills is just as difficult. One of the biggest challenges to academic writing skills development concerns providing timely, actionable feedback to help students improve their writings (Bernius et al. 2021).

Academic writing assessment is a labor-intensive task for teachers (Woods et al., 2017). It is time-consuming and demanding to deliver consistent, actionable feedback within large student cohorts. This issue, however, opens the opportunity for the automation of the feedback process, generated by Artificial Intelligence (AI).

There are numerous AI-supported tools for writing. They can be categorized into three main types based on the writing stage the system supports: the Intelligent Tutoring System (ITS) supporting the writing process; the Automated Writing Evaluation (AWE) for the editing and drafting; the Automated Essay Scoring (AES) for the post-writing stage (see Tubino, 2021 for more in-depth descriptions).

Automated Feedback falls under the AWE category, as it focuses on the lower-level concerns of academic writing and assists with the editing stage. Teachers can configure feedback criteria for students' assignments covering elements such as content, language, layout, references, tables and figures within the tool. Based on the configured rubric, Automated Feedback analyses the assignment and provides feedback for students. In this way, students can iterate on their assignments before submitting the final version, while teachers can reduce the reviewing workload to focus on higher-order concerns such as reasoning and content. To encourage self-reflection and facilitate comprehension of academic writing principles, the tool does not offer automatic corrections, but rather provides actionable suggestions that students can choose to incorporate into their work. As a result, Automated Feedback not only reduces the manual workload of the teacher, but also helps develop students' higher-order thinking skills and solidify the knowledge of academic writing principles. Most importantly, the tool can be integrated into different learning management systems (LMSs) to provide instant formative feedback on students' academic writing skills.

Automated Feedback is the result of the collaborative effort between Erasmus University Rotterdam, Rotterdam University of Applied Sciences, and FeedbackFruits. The project sought to harness the power of AI to increase the quality of students' products and stimulate deeper learning while freeing up time for teachers to provide higher-order feedback. The first iteration of Automated Feedback was launched in 2019 and has been supporting institutions worldwide to enhance the teaching and learning experience.

2. Goals and Development

An effective automated feedback system should assess text quality and construct actionable feedback for recognized text patterns in order to support teachers in reviewing writing assessment. This provides significant benefits to both teachers and students regarding time consumption, feedback availability, and feedback consistency. Ideally, an automated writing feedback system relies on educational principles to strive for constructive alignment of learning activities and learning

evaluation, as well as encourage long-term learning effects. Because localized, content-specific data is expensive to collect and annotate (Hellman et al., 2020), an efficient automated feedback system should strive to provide generalizable feedback across different types of assignments in various disciplines and topics. The main challenge in implementing the automated feedback system involves producing accurate feedback, which stimulates deeper learning and increases students' writing quality, as well as conducting sufficient evaluation of the process. Therefore, Automated Feedback has been developed with careful consideration of the aforementioned issues.

Automated Feedback uses a collection of both rule-based and machine learning-based Natural Language Processing (NLP) techniques to generate feedback based on criteria specified by the user. The developers utilize the programming language Python, various open-source models and algorithms as well as basic techniques as text classification, Part-of-Speech (POS) tagging, and Named Entity Recognition (NER) to build language models. The development team uses supervised learning to train the language models with manually collected data. In order to develop language models most appropriate for the current users, data collection is limited to selected academic domains, such as business and finance. With this limitation, the development team systematically searches for academic articles on various databases. In this process, the team locates data that are most relevant for the identified assignment types while trying to ensure regional and linguistic diversity in the data. The tool does not currently collect data from users.

When a user uploads their document, a document parser reads and parses the file into smaller elements. These elements are categorized into tagged chunks based on their visual and linguistic properties. Based on these tags, the machine generates feedback that is appropriate for the context.

Automated Feedback is different from the existing reviewing tools in its formative nature, as well as its primary focus on student learning and the development of higher-order thinking skills. The language models allow the tool to provide feedback not only on grammar and spelling, but also on the adherence to academic writing conventions, such as citation style, active voice, direct quotation usage, verb tense, vocabulary (for example, precise and concise writing). Figure 1 demonstrates how the tool provides feedback on a linking word and the references section in a draft of this paper. As a result, the tool decreases the time and effort spent on providing lower-order, while allowing teachers to focus on domain-specific, and personalized feedback. This, in turn, diversifies the learning activities during the course, further promoting constructive alignment.

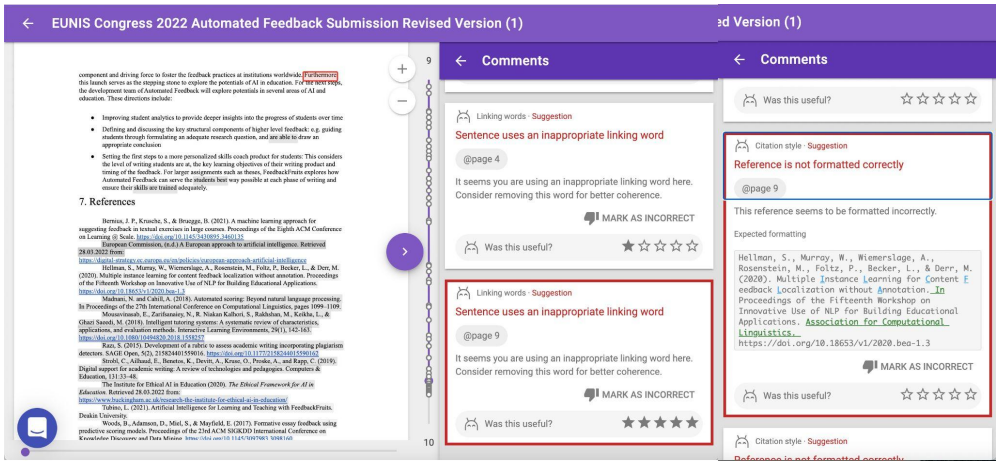

Figure 1: Annotations on the use of a linking word and a reference

Furthermore, Automated Feedback encourages students to participate in the active-reflective process, in which they actively improve their work, instead of relying on the tool to correct their work (see Figure 1). Automated Feedback improves the current existing feedback practices (such as peer feedback) by screening the lower-order mistakes in academic writing, spelling, and grammar, that distract teachers from focusing on the content of the assignments. In addition, the tool can be fully configured by the teacher to ensure that they remain the drivers of student learning and are not limited or inconvenienced by the technology. Teachers can tailor the tool to the type and level of the writing assignments. Instead of presenting suggestions of which the teacher has no control, the tool provides feedback based on teachers' configured rubrics. The given formative feedback allows students to review their work closely and decide on which comments to follow. Moreover, students cannot implement corrections with a click of a button – instead, they are invited to rate and object to the feedback while improving their writing products. This is an intentional design that seeks to encourage students to react to their writing and the feedback critically and proactively. As students undergo this analytical and decision-making process, the final product would be of holistic academic quality, not just a "well-written" or "well-formatted" writing piece.

Following the European Union's guidelines for trustworthy AI (European Commission, 2019) and The Ethical Framework for AI in Education (The Institute for Ethical AI in Education, 2020), the development process acknowledges the limitations of AI by giving teachers full transparency about the feedback given. Students are also empowered to be critical to system outcomes. There is regular and proactive quality assurance to evaluate the tool performance. In this process, the development team also collaborates closely with academic experts, who are invited to propose and test new feedback criteria. Furthermore, in order to ensure security and transparency and not rely on collecting user data, the tool uses its own corpora. This allows for a systematic approach, in which use cases from a specific domain are identified to conduct a systematic search on academic databases.

3. Main features and functionalities

Automated Feedback, as all FeedbackFruits tools, is integrated with the Learning Management Systems (LMS), such as Canvas, D2L Brightspace, Blackboard, or Moodle, allowing for easy access for both instructors and students. The tool serves as a supporting module for students to improve their writing before the final submission, thus was not designed to have a grading function. However, instructors can choose to include the Automated Feedback module within other LMS-integrated review tools of FeedbackFruits such as Peer Review and Assignment Review, for assignments to go through formative or summative peer review or teacher review process after the writing is improved. This contributes to providing students with multiple layers of feedback that address different aspects of writing.

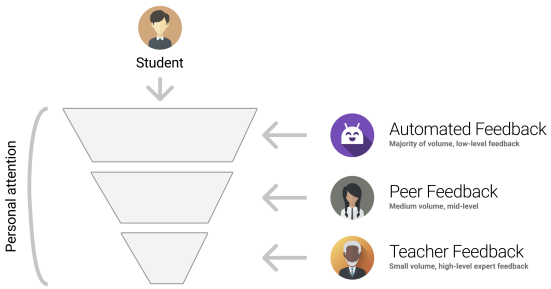

Figure 2: The three levels of feedback

The instructor takes charge of setting up Automated Feedback assignments. This process starts with the instructor filling in the assignment instructions. In this step, a collaboration option is available: the instructor can choose for their students to hand in work individually or as groups. If the tool is integrated to an LMS via API, the tool can automatically recognise any existing LMS groups. In this initial set-up process, the instructor can also set up a deadline and the required number of submissions.

Next, the instructor chooses the feedback criteria against which the students' work would be checked. Automated Feedback currently offers 26 feedback criteria, which are listed in Table 1. The criteria fall into five aspects of academic writing: Academic Language, Citing and Referencing, Content and Structure, Format, and Table and Figures. The development chose these criteria based on a rubric specified by Razı (2015) and in consultation with academic writing experts. They identified these elements of writing as some of the most commonly erred in academic writing. The criteria in Beta status may have a higher error rate than those in Stable status due to technological limitations.

CATEGORY	***STATUS***	***NAME***
Academic Language (limited multilingual support)	Stable	Abbreviation introduction (all languages)
		Grammar
		Personal pronouns
		Vocabulary - Concise writing - Distinguish commonly confused words - Proper word combinations
	Beta	Active voice
		Formal writing style - Avoid contractions - Avoid starting a sentence with coordinating conjunctions
		Punctuation - Oxford comma
		Spelling
		Verb tense
Citing and Referencing	Stable	Citation count of references
		Citation style
		Reference count
	Beta	In-text citation of references
		Reference content
Content and Structure	Stable	Document language (all languages)
		Required sections
		Sentence length

		Word count
Format	Stable	Page numbers
		Table of contents
Tables and Figures	Stable	Figure count
		Table count
	Beta	Figure captions
		In-text citation of figures
		In-text citation of tables
		Table captions

Table 1: FeedbackFruits Automated Feedback tool list of features

Finally, the instructor configures their preferred feedback criteria where applicable. For instance, if they have chosen the "word count" criterion, they can define the minimum and maximum word count that they expect in each document. Instructors can configure the criteria from scratch, or use templates that are provided by FeedbackFruits and readily available within the tool. Currently, there are four FeedbackFruits templates: case study, essay, research paper, and thesis. Before publishing the assignment, the instructor is encouraged to test their set-up by using the 'try-out' functionality to see the feedback students will receive with the defined criteria.

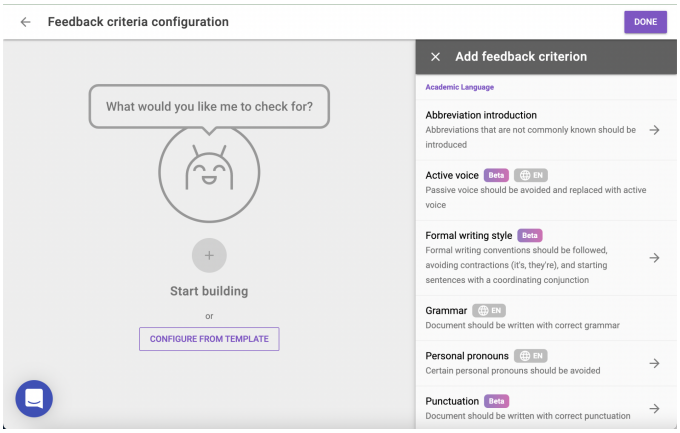

Figure 3: Configuration of criteria in Automated Feedback

A notable functionality to further save time for instructors is the 'copy from existing' feature. With this functionality, the instructor can copy a previous Automated Feedback assignment of their choice and adjust its settings if needed. Furthermore, it allows teachers to save time and ensure that the checks on academic writing can be a part of the evaluation of all future products. The previous student contributions are not copied in this process.

After an instructor completes set-up, students can upload their assignments. Automated Feedback reviews students' submissions based on the criteria set by the instructor. The tool provides in-line feedback as 'compliments' and 'suggestions.' Within the document, the tool highlights the text where feedback is given so that students can know where to adjust. Students are also able to mark any

given feedback as incorrect or skip it. The development team uses students' reactions to discover performance issues and improve feedback quality.

Once students upload their documents, the instructor is able to monitor the students' performance on the dashboard. They can choose to view the cohort's performance per criteria or an individual student's performance. The performance is given as a ratio of 'compliments' and 'suggestions.' If the instructor wishes to gain more insights into individual students' work, they can access the feedback in this step as well.

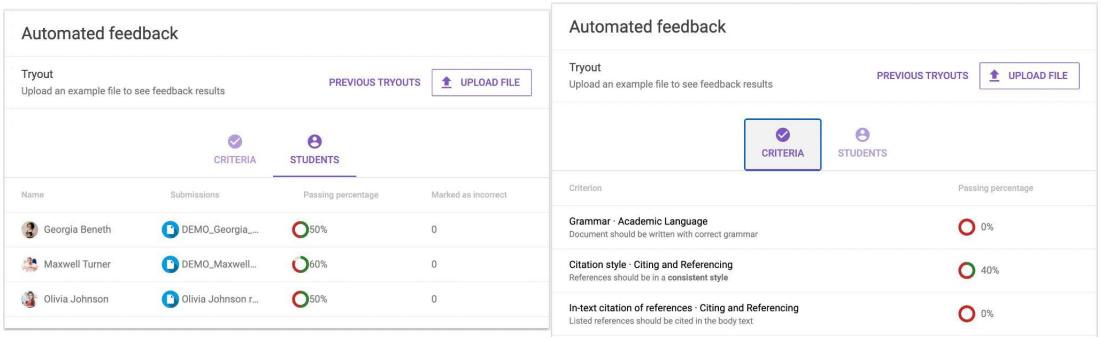

Figure 4: Analytic dashboard showing performance of students per criterion and per student

4. Implementation and results

Automated Feedback has piloted at seventeen institutions internationally, with thirteen in Europe, two in Australia, and four in the United States. The tool has been used to help instructors elevate the feedback process and improve students' writing skills, from the Saint Leo University, Bethune-Cookman University, the Evergreen State College, Fort Hays State University in the United States, to Erasmus University of Rotterdam, University of Amsterdam, University of Groningen in Europe to Griffith University, and Deakin University in Australia.

So far, five use cases were produced based on in-depth interviews with instructors from Avans University of Applied Sciences[1], Deakin University[2], Wageningen University & Research[3], University of Groningen[4] and University of Amsterdam[5] to report the implementation of the tool regarding adherence to the learning objectives, ease of use, student reactions, quality of experience, time involved, and improvement of learning outcomes. The use cases showcase the wide range of applications of the tool. For instance, while the tool used for business emails in the use case of the

[1] https://help.feedbackfruits.com/en/articles/5945583-use-case-grant-students-independence-and-enhance-written-communication-skills

[2] https://help.feedbackfruits.com/en/articles/5806815-use-case-generate-individualised-feedback-on-writing-in-larger-student-cohorts

[3] https://help.feedbackfruits.com/en/articles/5227277-use-case-enabling-higher-quality-peer-feedback-in-thesis-project-groups

[4] https://help.feedbackfruits.com/en/articles/4944604-use-case-using-automated-feedback-to-optimise-students-written-reports-in-an-english-language-course

[5] https://help.feedbackfruits.com/en/articles/5640147-use-case-reduced-student-anxiety-and-instructor-burden-in-a-business-administration-writing-class

Avans Business School, it was used for bachelor's theses in the use case of Wageningen University & Research. Other applications include research reports, academic reports and thesis proposals.

Moreover, the use case of University Amsterdam also emphasized the tool's anxiety-reducing effect in the thesis-writing process for students from non-academic backgrounds. Especially during the pandemic, receiving more feedback throughout a challenging process provided a confidence boost for the students.

Lastly, the use cases showcase the consistent quality of the user interface across different learning management systems. For instance, Avans Business School integrated the tool into Brightspace, while the University of Amsterdam configured it within Canvas.

The limitations of the tool mentioned by users included processing large documents and their meaning, domain-specific language, and the lack of linguistic resources. While there has been significant development in NLP in the past decades, the industry witnesses many challenges. Due to the fact that context and domain-specific knowledge are central in providing sound judgment of academic writing, argumentation, and reasoning, the lack of capacity in language models to do so presents this problem as a difficult obstacle. In order to ensure that the feedback is sufficiently contextualized and personalized, the development team actively and constantly conducts technical experimentation.

It was also noted that the influence of AI-powered pedagogical tools comes not only from the technology, but also its presentation of pedagogical value and learning activities. To further facilitate effective pedagogical practices, further investment is needed in fostering feedback literacy, evaluative judgment, and self-regulated learning through providing informative guidance on academic writing conventions and actionable suggestions.

5. Impact and benefits

While there has not been an empirical study on the efficacy of Automated Feedback, the team seeks to track metrics that provide direct insights into the effectiveness of this tool in improving academic writing in university settings. So far, over 3000 known users (teachers and students) registered and had their writings reviewed by Automated Feedback. To measure students' engagement with Automated Feedback, the development team constantly monitors the number of submissions and points of feedback provided within the tool. As of February 7, 2022, over 60.000 points of feedback were given automatically in about 5000 submissions across three regions. FeedbackFruits uses CSAT (Customer Satisfaction Score) to measure students' overall satisfaction with the tool and how they perceive the quality of generated feedback. The majority (70%) of the students reported that they were satisfied with using the tool in CSAT. The usefulness rating is 4.04 out of 5 based on around 1600 responses. This means that students found the Automated Feedback useful and valuable. One responder noted that the feedback provided by the tool "helps them a lot with things they would not have thought of otherwise". The development team also tracks resubmission rate, which could indicate whether the students engage with the feedback and iterate on their work. Currently, 21% of submissions are followed by a resubmission.

6. Future development

The development team of Automated Feedback continuously works to innovate and improve the tool according to two core values: saving teachers time and improving the writing quality of

students. To achieve this, a close collaboration with experts and consultation with their experiences is maintained for future developments (such as new feedback criteria). The long-term goal is to make it into a tool that sets domain-independent standards, while adapting to the needs of students and teachers and the intended pedagogical approach.

Automated Feedback Version 1.0 was launched in March 2022. This upgraded version has received validation across a wide range of domains. This new version is expected to serve as a key component and driving force to foster the feedback practices at institutions worldwide. Furthermore, this launch serves as the stepping stone to explore the potentials of AI in education. For the next steps, the development team of Automated Feedback will explore potentials in several areas of AI and education. These directions include:

- Improving student analytics to provide deeper insights into the progress of students over time
- Defining and discussing the key structural components of higher level feedback: e.g. guiding students through formulating an adequate research question, and are able to draw an appropriate conclusion
- Setting the first steps to a more personalized skills coach product for students: This considers the level of writing students are at, the key learning objectives of their writing product and timing of the feedback. For larger assignments such as theses, FeedbackFruits explores how Automated Feedback can serve the students best way possible at each phase of writing and ensure their skills are trained adequately.

7. References

Bernius, J. P., Krusche, S., & Bruegge, B. (2021). A machine learning approach for suggesting feedback in textual exercises in large courses. Proceedings of the Eighth ACM Conference on Learning @ Scale. https://doi.org/10.1145/3430895.3460135

European Commission, (2019) A European approach to artificial intelligence. Retrieved 28.03.2022 from: https://digital-strategy.ec.europa.eu/en/policies/european-approach-artificial-intelligence

Hellman, S., Murray, W., Wiemerslage, A., Rosenstein, M., Foltz, P., Becker, L., & Derr, M. (2020). Multiple instance learning for content feedback localization without annotation. Proceedings of the Fifteenth Workshop on Innovative Use of NLP for Building Educational Applications. https://doi.org/10.18653/v1/2020.bea-1.3

Madnani, N. and Cahill, A. (2018). Automated scoring: Beyond natural language processing. In Proceedings of the 27th International Conference on Computational Linguistics, pages 1099–1109.

Mousavinasab, E., Zarifsanaiey, N., R. Niakan Kalhori, S., Rakhshan, M., Keikha, L., & Ghazi Saeedi, M. (2018). Intelligent tutoring systems: A systematic review of characteristics, applications, and evaluation methods. Interactive Learning Environments, 29(1), 142-163. https://doi.org/10.1080/10494820.2018.1558257

Razı, S. (2015). Development of a rubric to assess academic writing incorporating plagiarism detectors. SAGE Open, 5(2), 215824401559016. https://doi.org/10.1177/2158244015590162

Strobl, C., Ailhaud, E., Benetos, K., Devitt, A., Kruse, O., Proske, A., & Rapp, C. (2019). Digital support for academic writing: A review of technologies and pedagogies. Computers & Education, 131:33–48.

The Institute for Ethical AI in Education (2020). *The Ethical Framework for AI in Education.* Retrieved 28.03.2022 from: https://www.buckingham.ac.uk/research-the-institute-for-ethical-ai-in-education/

Tubino, L. (2021). Artificial Intelligence for Learning and Teaching with FeedbackFruits. Deakin University.

Woods, B., Adamson, D., Miel, S., & Mayfield, E. (2017). Formative essay feedback using predictive scoring models. Proceedings of the 23rd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining. https://doi.org/10.1145/3097983.3098160

8. Authors' biographies

Ziwei (Jo) Huang is the AI Product Owner at FeedbackFruits, currently working on Automated Feedback and other AI products. Previously, she worked as a product and user researcher at various EdTech and consumer product companies. She received an MSc (Distinction) in Applied Linguistics and Second Language Acquisition from the Department of Education at Oxford University and a BA in Linguistics (honors) and Organizational Studies (International Education) from Pitzer College. She has presented her research on pragmatics at the EPICS VIII Conference.
Jo welcomes collaboration opportunities in education and technology, especially in efficacy research. She can be contacted at jo@feedbackfruits.com.

Wilco te Winkel has a master's degree in Information Management and has been working at Erasmus University Rotterdam since 2001. He worked for 8 years as a university lecturer and then later held the roles of Information Manager, IT Demand Manager, Education Innovation Team Manager, Interim Education Bureau Manager, Interim Education Marketing Coordinator, Interim Education Research Profiling Manager for 7 years at Erasmus School of Social and Behavioural Sciences. Since 2019, he has been working as the Information Manager at Erasmus University of Rotterdam. He has given over 35 presentations in various conferences since 1998 and currently has 19 publications.