INTELLIGENT ENOUGH? ARTIFICIAL INTELLIGENCE FOR ONLINE LEARNERS

Eunjyu Yu, SUNY Canton

ABSTRACT

Artificial intelligence (AI) is increasingly being used as a cost-effective assistant to human instructors to generate performance feedback for online learners. This study found that AI-generated feedback had a positive impact on students' writing practice in an online learning space. Underperforming students stated that they wanted AI to further assist them with their content development skills and use of sources. Although most AI feedback was text-based, the students with different learning styles concurred that AI-generated feedback helped improve their writing skills, metacognitive skills, and self-confidence, but not their creativity. Student-driven suggestions reflect their desire for AI assistants to provide meaningful feedback to online learners that is personalized to meet their needs and to help them develop ownership of their learning.

Keywords: *artificial intelligence, online learning, intelligent feedback for writers*

INTRODUCTION

During the COVID-19 pandemic, students earned a new title, the Quarantine Generation, for those who have experienced quarantine. As the pandemic lockdowns drove teachers to convert in-person teaching to online or remote education, their attention was drawn to various emerging technologies to simulate an in-person learning environment for online learners.

As a cost-effective substitute for human instructors, automated feedback on student performance has been used for courses such as writing courses. However, conflicting findings were reported on the impact of automated feedback on student learning outcomes (Budge, 2011; Chong, 2019; Cox et al., 2015; Delante, 2017; Ene & Upton, 2018; Mulliner & Tucker, 2017).

With a recent advance in machine learning and big data technology, artificial intelligence (AI) powered applications have become available for education. Various AI-operated educational programs are welcomed by colleges and large-scale online learning entities looking for cost-efficient alternatives to human resources or as implements for large enrollment classes. Despite its increasing popularity, little is known about the impact of AI-generated feedback on student learning outcomes (i.e., communication skills), particularly when in-person student support is limited because of the pandemic.

Thus, it is critical to investigate the impact of AI-powered feedback on student learning outcomes to optimize online learning environments. This study aims at identifying effective AI-assisted composition pedagogy that would help college students become successful writers in online learning spaces. The focus is on online learners' attitudes and experience of AI-generated feedback provided by SafeAssign, Grammarly, and Packback. These programs were chosen because each AI offers different types of feedback, including essential plagiarism detection and inquiry-based metacognitive feedback. There is a need to investigate the impact of various AI feedback on writing practice.

The research questions are as follows:

1. What are students' attitudes toward AI-generated feedback on their writing?

2. How does AI-generated feedback impact students' writing practice?

3. What other features do students want to see?

BACKGROUND

Feedback for Written Communication Skills

Defined as "the development and expression of ideas in writing," written communication is the collective outcome of rhetorical knowledge, content development skills, knowledge of disciplinary conventions, research skills, and language usage (Association of American Colleges and Universities; AACU, 2009). Effective written communication skills are increasingly demanded in various communication channels and are among the most wanted skills in the age of Industry 4.0 (World Economic Forum, 2018).

The college students from upper-level online communication courses indicated that having 24/7 easy accessibility and self-paced learning were the most favorable online learning features (Yu, 2020). In addition, they stressed that the keys to success in online learning spaces are timely dynamic interactions with instructors, engagements with peers, and easy access to resources. These findings concur with the self-determination theory that supportive and contextualized interactions motivate learners to achieve their desired performance (Deci & Ryan, 2002; Ryan & Deci, 2000).

Furthermore, the importance of teacher feedback is noted because writing often needs numerous revisions (National Council of Teachers of English, 2015). Tailored feedback enriches interactions with students, but it also enhances teacher presence in online learning spaces.

Types of Feedback

Feedback is any critique serving to improve and/ or evaluate a student's learning. In terms of its function, there are four types of feedback: performance, motivational, attributional, and strategy (Schunket et al., 2014). Specifically, performance feedback explains how well a student performs on a given task. Motivational feedback aims to nudge a student into reaching a benchmark. Attributional feedback is an in-depth analysis ascribing performance to a student's particular skills. Strategy feedback focuses on what strategy a student needs to perform better. Each specialized feedback can be used alone or together in different combinations to serve different purposes.

Considering the crucial role of teacher feedback, it would be ideal that an instructor proactively initiates feedback in addition to scheduled feedback. In reality, however, it might not always be feasible for teachers to give timely feedback at each step of the multilayered writing process because of heavy teaching loads and large class sizes. This reality is far from the recommended course cap of 15 or fewer students (Farrell & Jensen, 2000). Various technologies can bridge the gap between the ideal and the reality.

Technology for Feedback

Traditionally, feedback on a student's academic performance was provided by an instructor vocally in an in-person setting until the beginning of distance education by mail in the late 1800s (Jonassen et al., 2008). The exponential growth of computer technology has expanded the sustainability of feedback in various digital formats, including digital audio, digital video, real-time text chat, live streaming, and emoticons, as well as conventional oral and written comments, to meet the increasing demand for multimedia resources (Yu, 2020).

Also, the accessibility of feedback has been enhanced by diversifying its delivery mode. Since 1964, as an alternative to human raters, Project Essay Grader has used essay scoring robots to evaluate writing performance automatically and generate feedback on writing tasks (Page, 1967; Srivastava et al., 2020). Feedback goes hand-in-hand with assessment because meaningful feedback is based on adequate assessment. Upgraded by an adaptive learning system and big data technology, an intelligent tutor was first introduced in 1977 (Scandura, 2018). Like the human brain, the machine continues to evolve its intelligence by learning for itself and has the ability to "function appropriately and with foresight in its environment" (Nilsson, 2009, p. 13). Today's AI can process written messages and give real-time feedback on writing without human supervision (Press, 2016). AI-generated feedback can be delivered without the restrictions of time and place.

Over the past few decades, the role of automatic feedback has evolved from a simple error corrector to an advanced metacognition stimulus. Earlier automated feedback was limited to error corrections. For example, as an automated proofreader, Microsoft Word helps writers edit sentence-level errors, including grammar, mechanics, spelling,

word choice, and citations. Later, the internet-based SafeAssign was developed to detect plagiarism. SafeAssign runs writing drafts against large-scale databases and provides immediate explanations for revisions (Blackboard, 2022).

AI has become more sophisticated and now provides tailored feedback thanks to machine learning technology. AI stimulates learners' cognitive ability and autonomy by giving metacognitive as well as cognitive feedback. For instance, Grammarly provides real-time feedback on writing style and tone along with proofreading and plagiarism detection services. The AI-based Grammarly Editor generates tailored feedback and revision suggestions in terms of correctness, clarity, engagement, and delivery (Grammarly, 2020).

Developed for online discussions, AI-powered Packback provides instant feedback to both students and instructors (Packback, 2022). Packback features various built-in nudges designed specifically for students. Similar to the Facebook "Like" button, the Packback "Spark" button promotes interactions among students by allowing them to visualize their reactions to other posts. This button also drives students to write more audience-centered posts to get high "curiosity scores." The "Add response" button and the source identification box lead students to reflect on their writing strategies. Moreover, Packback supports instructors by providing summaries of students' participation using a guideline for personalizing feedback.

Learner Characteristics

Successful feedback begins with a good understanding of learners' needs and interests. This study focused on learners' cognitive ability and learning styles.

Cognitive Ability

Defined as a capacity to internalize new information and utilize it to achieve desired goals, cognitive ability is a crucial predictor of student success (Li & Wong, 2021; Sternberg, 2005). In this study, the cognitive ability of the research participants was presented by their grades on various writing tasks.

The writing tasks included a 250-word self-introduction essay, a 250-word report on cross-cultural communication and communication ethics, a 400-word research project proposal, and a 1,300-word research paper. The tasks were evaluated in five categories: rhetorical knowledge, content development skills, knowledge of disciplinary conventions, research skills, and grammar/mechanics.

The highest score for the essay, report, and proposal was 10 points each, and the highest score for the research paper was 20 points. The students who earned a B (80% of the 50 total assignment points) or higher were identified as High-Performing Students, while the rest were considered Underperforming Students.

It is not unusual that students' grades in the same course range widely from an A to an F. Thus, it is vital to identify how differently learners at distinct academic levels would interact with various feedback resources and customize their learning experiences accordingly.

VARK Learning Styles

Based on "sensory modality preference" (p. 2), Fleming and Mills (1992) introduced the VARK model to explain four different learning styles. As presented in Table 1, Visual learners prefer information presented graphically; Aural learners prefer information presented vocally; Read/Write learners prefer written information; and Kinesthetic learners prefer learning through hands-on experience (VARK Learn Limited, 2022).

Different learners process new information in different ways. Online learning spaces have adopted multimodal interfaces to accommodate demands for various delivery modes and supported learners to interact with multimodal information. Course materials are presented in various modes,

Table 1. Summary of the VARK Learning Styles

Learning style	Sensory modality preference	Sample learning activities
Visual learners	Graphic	Using visual aids like graphs, tables, and maps
Aural learners	Vocal	Listening to lectures or participating in discussions
Read/Write learners	Written	Reading books or taking notes
Kinesthetic learners	Hands-on	Using real-life examples

Table 2. Descriptive Summary of the Participants

Ethnicity	Major	Campus
64.7% White (not of Hispanic origin)	76.5% Business	47% Public universities
13.2% Asian or Asian American	5.9% Legal Studies	53% Private universities
11.8% African or African American	5.9% Liberal Arts	
7.4% Hispanic or Latino	4.4% Information Technology	
2.9% Other	2.9% Education	
	2.9% Graphic Design	
	1.5% Game Design	

including text, audio, video, virtual reality, augmented reality, and live streaming.

On the other hand, most automated feedback, including AI-generated feedback, is presented heavily in text. Little is known about how learners with different modality preferences interact with text-based feedback. This study addresses that gap.

METHOD

Research Contexts and Participants

A total of 68 volunteers were recruited from an upper-level communication course. The course was designed to advance communication skills with a focus on technical writing skills. Different types of writing tasks were assigned weekly, along with reading assignments. This online course ran asynchronously on the Blackboard platform of a public university. Students from public and private universities across the Northeast were enrolled in the course.

The participants were between 18 to 53 years old, and 71% were Gen Z and born in 1995 or later (Yu, 2020). In terms of gender, 60% of the participants self-identified as female and 38% as male. One participant chose not to disclose. As seen in Table 2, the participants came from diverse backgrounds.

The participants' preferences for course modality were spread evenly. Specifically, 38.2% of the participants preferred a hybrid mode, 30.9% chose in-person, and 30.9% preferred entirely online. Regarding feedback sources for developing their writing skills, teachers (83.8%) were ranked the most favored feedback source, followed by AI-generated feedback (26.5%), writing center tutors (23.5%), and peers (23.5%). The students seemed to value teachers' feedback the most.

Procedures

A questionnaire was developed to collect quantitative and qualitative data. The Written Communication Rubric developed by the AACU (2009) and the VARK learning styles were adopted to enhance the instrument's validity. This online questionnaire asked the participants about their demographic background and their experience using AI-generated feedback.

In this study, AI-generated feedback means feedback on writing tasks provided by artificial intelligence. Specifically, the participants were required to use AI-based feedback programs such as Packback, SafeAssign, and Grammarly, all available at the research site. Packback and SafeAssign were built in Blackboard, and a free premium version of Grammarly was offered to all participants. Each program featured different types of feedback, as highlighted in Table 3.

As mentioned earlier, the writing tasks included an essay, a report, a research project proposal, and a research paper. As the essay and the report assignments were developed for the Packback-based discussion forum, responding to other student posts was mandatory to facilitate student interactions and peer feedback.

The participants were surveyed in the final week of the course. The SPSS statistical software was used to conduct t-tests and ANOVA. The response patterns of the questionnaire were categorized.

RESULTS

RQ 1. What are students' attitudes toward AI-generated feedback on their writing?

Attitude Toward AI-generated feedback by

Table 3. Descriptive Summary of the AI-based Feedback Programs

Tool	Feature	Feedback type	User	Turnaround time
SafeAssign	plagiarism detection	performance-oriented; cognitive feedback on plagiarized sentences; useful for summative assessment;	students and teachers	instant feedback after paper submission
Grammarly	plagiarism detection; proofreading; tailored feedback on writing style and tone; generating revision suggestions in terms of correctness, clarity, engagement, and delivery	improvement-oriented; tailored feedback; useful for revision	students	real-time feedback while writing
Packback	facilitating engaged discussions; monitoring and grading discussion posts; providing teachers with summaries of student participation and feedback tips	engagement-oriented; motivational and metacognitive feedback; useful for formative feedback/assessment	students and teachers	real-time feedback while writing

Cognitive Ability

The students' writing assignment scores ranged from 33 to 48.5, with a mean of 42.5. As mentioned earlier, 40 is equal to 80% of the 50 total assignment points and was used as a cut-off score for high-performing students. Out of 68 participants, 91% were high-performing students, and 9% were underperforming students.

The sample sizes of the two groups were different, but the homogeneity of variances was met. The t-tests were conducted to verify whether there were any significant differences in the students' attitudes toward AI-generated feedback. Seven questions were used to measure attitudes toward AI-generated feedback. As presented in Table 4, the high-performing students reported that the AI-generated feedback helped improve their revision skills, writing performance, self-confidence, and metacognitive skills. Meanwhile, the underperforming students did not appreciate AI-generated feedback.

The results of the t-tests confirmed that significant differences were observed between the two groups in the comfort of using AI-generated feedback ($t(66) = 2.51$, $p < .05$) and AI's impact on

Table 4. Results of Independent Samples t-tests between Attitude and Cognitive Ability

	High-performing		Underperforming		t-test
	Mean	SD	Mean	SD	
Are you comfortable using AI-generated feedback to improve your writing?	3.35	.79	2.50	.83	2.51*
Does AI-generated feedback help improve your writing performance?	3.34	.70	2.83	1.16	1.58
Does AI-generated feedback help improve your writing strategies?	2.84	.87	2.33	1.03	1.33
Does AI-generated feedback motivate you to revise and improve your writing?	3.18	.85	2.50	.83	1.84
Does AI-generated feedback motivate you to reflect on and evaluate the development of your writing practices?	2.94	.74	2.17	.98	2.35*
Does AI-generated feedback increase your self-confidence as a writer?	3.02	.87	2.67	.81	0.93
Does AI-generated feedback promote your creativity?	2.31	.87	2.17	1.16	0.36

* $p < 0.05$, SD = Standard Deviation   Number of high-performing students = 62, Number of underperforming students = 6

1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Somewhat Agree, 4 = Strongly Agree

Table 5. Descriptive Statistics for Responses by Attitude and Learning Style

Attitude toward	Learning style	N	Mean	SD	95% Confidence Interval Lower	95% Confidence Interval Upper
Comfort of using AI	Aural	6	3.00	1.26	1.67	4.33
	Visual	25	3.12	1.01	2.70	3.54
	Read/Write	15	3.47	.64	3.11	3.82
	Kinesthetic	22	3.41	.50	3.19	3.63
Writing performance	Aural	6	3.50	.54	2.93	4.07
	Visual	25	3.04	1.02	2.62	3.46
	Read/Write	15	3.53	.51	3.25	3.82
	Kinesthetic	22	3.36	.49	3.15	3.58
Writing strategies	Aural	6	3.33	.81	2.48	4.19
	Visual	25	2.68	1.06	2.24	3.12
	Read/Write	15	3.13	.74	2.72	3.54
	Kinesthetic	22	2.55	.67	2.25	2.84
Revision skills	Aural	6	3.50	.54	2.93	4.07
	Visual	25	2.88	1.16	2.40	3.36
	Read/Write	15	3.27	.70	2.88	3.66
	Kinesthetic	22	3.18	.58	2.92	3.44
Metacognitive skills	Aural	6	3.17	.40	2.74	3.60
	Visual	25	2.64	.99	2.23	3.05
	Read/Write	15	3.07	.70	2.68	3.46
	Kinesthetic	22	2.91	.61	2.64	3.18
Self-confidence	Aural	6	3.33	.81	2.48	4.19
	Visual	25	2.84	.98	2.43	3.25
	Read/Write	15	3.33	.72	2.93	3.73
	Kinesthetic	22	2.82	.79	2.47	3.17
Creativity	Aural	6	2.83	.75	2.04	3.62
	Visual	25	2.24	.92	1.86	2.62
	Read/Write	15	2.47	.91	1.96	2.97
	Kinesthetic	22	2.09	.86	1.71	2.48

1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Somewhat Agree, 4 = Strongly Agree

metacognitive skills (t(66) = 2.35, p < .05). In other words, the high-performing students felt comfortable using AI to improve their writing skills and asserted that AI-generated feedback enhanced their metacognitive skills and autonomy. However, the underperforming students reported that their overall writing performance was moderately improved, but they did not feel comfortable using AI or experience a positive impact on their autonomy.

Attitude toward AI-generated Feedback by Learning Style

Concerning the VARK learning styles, the participants had preferences for visual (37%), followed by kinesthetic (32%), read/write (22%), and aural (9%). The sample sizes of each group were different, but the homogeneity of variances was met.

The one-way analysis of variance (ANOVA) was used to determine if any significant mean differences were observed between the groups. As seen in Table 5, the overall student attitude

was positive to AI-generated feedback regardless of their learning styles. The students reported that AI-generated feedback helped improve their writing skills, metacognitive skills, and self-confidence, but not their creativity.

As presented in Table 6, the results of the ANOVA verified that the observed mean differences between groups were not statistically meaningful. In other words, the AI-generated feedback used for this study was heavily text-based; however, these results imply that students' learning styles are not associated with their attitudes toward AI-generated feedback.

RQ 2. How does AI-generated feedback impact students' writing practice?

Based on the AACU Written Communication Rubric (2009), the following five items were developed to identify the impact of AI-generated feedback on students' writing practice:

- Does AI-generated feedback help enhance your rhetorical knowledge to effectively respond to contexts, audiences, and purposes of the assigned writing tasks?
- Does AI-generated feedback help strengthen your ability to use appropriate content to illustrate mastery of the subject?

Table 6. Results of ANOVA by Attitude and Learning Style

Source		Sum of Squares	df	Mean Square	F	P-value
Comfort of using AI	Between Groups	2.00	3	.66	.97	.41
	Error	43.69	64	.68		
	Total	45.69	67			
Writing performance	Between Groups	2.83	3	.94	1.71	.17
	Error	35.28	64	.55		
	Total	38.11	67			
Writing strategies	Between Groups	5.15	3	1.71	2.29	.08
	Error	47.96	64	.74		
	Total	53.11	67			
Revision skills	Between Groups	2.71	3	.90	1.19	.31
	Error	48.34	64	.75		
	Total	51.05	67			
Metacognitive skills	Between Groups	2.46	3	.82	1.33	.27
	Error	39.34	64	.61		
	Total	41.80	67			
Self-confidence	Between Groups	3.68	3	1.22	1.66	.18
	Error	47.29	64	.73		
	Total	50.98	67			
Creativity	Between Groups	3.17	3	1.05	1.32	.27
	Error	50.94	64	.79		
	Total	54.11	67			

* $p < 0.05$

- Does AI-generated feedback help enhance your ability to use discipline-specific conventions such as organization, presentation, formatting, and stylistic choices?
- Does AI-generated feedback help enhance your ability to use sources to develop appropriate ideas for the discipline and genre of the writing?
- Does AI-generated feedback help enhance your ability to communicate with clarity, fluency, and no errors of mechanics, grammar, and usage?

This rubric measured five aspects of writing skills: rhetorical knowledge, content development skills, knowledge of disciplinary conventions, the use of sources, and grammar/mechanics.

AI's Impact on Students' Writing Practice by Cognitive Ability

As presented in Table 7, the high-performing students reported that the AI-generated feedback improved their overall writing skills. Meanwhile, the underperforming students reported that AI helped strengthen their rhetorical knowledge, knowledge of disciplinary conventions and grammar/mechanics, but not content development skills

or the use of sources. The results of the t-tests confirmed that the mean differences between the two groups were not statistically significant. However, it is worth noting that underperforming learners need additional support for fostering their content development skills and ability to use sources.

AI's Impact on Students' Writing Practice by Learning Styles

As seen in Table 8, the Read/Write learners noted that AI-generated feedback helped improve all five aspects of their writing skills. Interestingly, the rest of the participants found that AI-generated feedback helped improve their knowledge of disciplinary conventions and grammar/mechanics, but not their rhetorical knowledge, content development skills, or the use of sources.

As presented in Table 9, the results of the ANOVA verified that the observed mean differences between groups were not statistically meaningful. These results imply that they agreed on the overall impact of AI-generated feedback on their writing practice regardless of their learning styles. In other words, they all concurred that AI-generated feedback helped enhance their knowledge of disciplinary conventions and grammar/mechanics.

Table 7. Independent Samples t-tests between AI's Impact and Students' Cognitive Ability

	High-performing		Underperforming		t-test
	Mean	SD	Mean	SD	
Rhetorical knowledge	2.84	.83	2.83	1.16	0.01
Content development skills	2.74	.88	2.17	.98	1.50
Knowledge of disciplinary conventions	3.06	.74	2.83	1.16	0.69
Use of sources	2.68	.93	2.17	.75	1.29
Grammar/mechanics	3.52	.71	3.00	1.26	1.56

* $p < 0.05$, SD = Standard Deviation

Number of high-performing students = 62, Number of underperforming students = 6

1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Somewhat Agree, 4 = Strongly Agree

Table 8. Descriptive Statistics for Responses by AI's Impact and Learning Styles

Writing skills	Learning styles	N	Mean	SD	95% Confidence Interval	
					Lower	Upper
Rhetorical Knowledge	Aural	6	2.33	1.03	1.25	3.42
	Visual	25	2.72	.93	2.33	3.11
	Read/Write	15	3.13	.64	2.78	3.49
	Kinesthetic	22	2.91	.81	2.55	3.27
Content development skills	Aural	6	2.50	1.04	1.40	3.60
	Visual	25	2.68	1.06	2.24	3.12
	Read/Write	15	3.00	.75	2.58	3.42
	Kinesthetic	22	2.55	.73	2.22	2.87
Knowledge of disciplinary conventions	Aural	6	3.00	.63	2.34	3.66
	Visual	25	2.88	.88	2.52	3.24
	Read/Write	15	3.33	.61	2.99	3.68
	Kinesthetic	22	3.05	.78	2.70	3.39
Use of sources	Aural	6	2.83	1.16	1.61	4.06
	Visual	25	2.40	.95	2.00	2.80
	Read/Write	15	3.13	.74	2.72	3.54
	Kinesthetic	22	2.50	.85	2.12	2.88
Grammar/ mechanics	Aural	6	3.83	.40	3.40	4.26
	Visual	25	3.16	1.06	2.72	3.60
	Read/Write	15	3.67	.48	3.40	3.94
	Kinesthetic	22	3.59	.50	3.37	3.81

1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Somewhat Agree, 4 = Strongly Agree

Table 9. Results of ANOVA Tests between AI's Impact and Learning Styles

Source		Sum of Squares	df	Mean Square	F	P-value
Rhetorical knowledge	Between Groups	3.29	3	1.09	1.53	.21
	Error	45.92	64	.71		
	Total	49.22	67			
Content development skills	Between Groups	2.12	3	.70	.86	.46
	Error	52.39	64	.81		
	Total	54.51	67			
Knowledge of disciplinary conventions	Between Groups	1.94	3	.64	1.06	.37
	Error	38.92	64	.60		
	Total	40.86	67			
Use of sources	Between Groups	5.74	3	1.91	2.35	.08
	Error	52.06	64	.81		
	Total	57.80	67			
Grammar/mechanics	Between Groups	4.09	3	1.36	2.37	.07
	Error	36.84	64	.57		
	Total	40.94	67			

Table 10. Summary of Preferences for Feedback Types

Type of Feedback	Grade		Total
	HP	UP	
Attributional feedback	3 (5%)	0 (0%)	3 (4%)
Motivational feedback	18 (29%)	2 (33%)	20 (29%)
Performance feedback	12 (19%)	2 (33%)	14 (21%)
Strategy feedback	29 (47%)	2 (33%)	31 (46%)
Total	62	6	68

HP = High-performing students, UP = Underperforming students

*p < 0.05

RQ 3. What other features do students want to see?

Table 10 presents the frequency of participants' responses to a question: "What types of feedback would help you perform at your best?" Strategy feedback (47%) was the most favored feedback type to the high-performing students, followed by Motivational feedback (29%), Performance feedback (19%), and Attributional feedback (5%). Meanwhile, the underperforming students' preferences were evenly spread across Strategy feedback (33%), Motivational feedback (33%), and Performance feedback (33%).

As the sample size of the underperforming students was too small to conduct chi-square tests, it was not meaningful to compare the results between the high-performing students and the underperforming students. However, it is noteworthy that most of the participants indicated Strategy feedback (46%) and Motivational feedback (29%) as the most effective feedback.

When asked, "What features of AI-generated feedback help you improve your writing the most?" the majority of the participants (66%) chose AI-operated grammar correction. One participant mentioned, "grammar correction is helpful for turning a proofread corrected paper without any human errors or mistakes when reading a final draft over before submission." The second helpful feature was sentence restructuring (18%), as noted in the following comment, "offer of alternative words, spelling, punctuation, and how to arrange sentences to read in a more active voice," followed by plagiarism detection (3%).

Meanwhile, when asked, "What are the challenges of using AI-generated feedback for your writing?" 35% of the participants pointed out the lack of creativity. They stressed that "there is a specific way one would want to state an idea, and this does not always agree with the AI" and "AI does not understand context, figurative language, or expression behind the writing." They mentioned, "AI-generated feedback could limit creativity, take away from a writer's true writing style, and possibly get in the way when writing" because of "[AI's] inability to understand writing style versus grammatical propriety."

In addition, 26% of the students mentioned that "the AI-generated suggestions don't portray exactly what I am trying to say or don't make sense in the context." They explained that "something may appear really good to AI, but to a human reader, it could sound very choppy and bad" because AI relies on "algorithms rather than humans." Some AI-generated feedback was described as "blunt and vague" (9%) and "impersonal and generic" (7%). Technical issues (7%) were noted in the following comments: "I need Wi-Fi to use it. If I don't have a good Internet connection…then I can't use it." and "Sometimes the software is slow or has ad walls." and "Some are hard to navigate."

Concern about their dependency on AI (6%) was addressed in the following comments: "We can rely on [AI] too much, and we can use it and not learn from it. We just plug in our paper but don't learn why it's better this way than before." and "Relying too much on AI could possibly lead to a reduced proficiency." Last, three participants noted the lack of real-time interaction with AI. One mentioned that "If I have a question or want advice, AI is not really the way to go as it cannot have an actual conversation."

Indeed, eight suggestions were made to answer the question, "What additional features do you want to see?" First, the students wanted AI to check their citations (i.e., in-text citations) to avoid

plagiarism, as expressed in the comment, "checking for plagiarism and helping with in-text citations are so important for my writing because I constantly mix up the different kinds of citations."

Second, layout feedback was desired, as described in the following comments: "Something that can help me structure my writing in a better way (e.g., switching around paragraphs or examples to make a stronger point)" and "Templates for specific cases. Examples include scripts, academic journals, and creative writing. Templates could give suggested examples like a rubric on what could be used for that specific writing purpose." Most AI-generated feedback is limited to the sentence level. The AI programs seem not to be advanced enough to help users revise the overall writing flow and provide proper strategies.

Third, the need for a source recommendation engine was expressed in the following comment: "It would be great if AI could see the topic I am writing about and offer me links to valid websites or online libraries (maybe a school library) to provide further information on the subject where I can do more research if needed or wanted." A recommendation engine would help enrich their writing content by providing the most relevant suggestions through machine learning algorithms.

Fourth, the students wanted to personalize their writing style to fit a specific context and purpose, as addressed in the following comments:

"I would like to see AI that could be set for different fields and writing styles."

"I would also like to use suggestions for more informal writing styles like blogging or creative writing."

"The ability to change the level of professionalism in which the AI analyzes writing. This would go far to cater my writing to the level of my audience." and

"Ability to provide suggestions and feedback based on my personal writing style."

Fifth, tailored tutoring on frequent errors was desired, as noted in the following comments:

It would be helpful if AI could provide more statistics on my writing about common errors I have made. Then, they could show my progress with fixing these errors.

These sources could even link to articles or videos that teach about these same common errors.

Practice questions with key concepts that the AI picks up in my writing (i.e., if I needed help with grammar, the AI could provide me with some grammar practice questions so that the AI system does not need to keep correcting it on my writing)

Sixth, they wanted to see a wide range of rewording suggestions, as explained in the following comments: "Sometimes…there is a point where I am trying to convey, but I forget the particular word that would convey my point. I want AI to help me come up with words I blank on." and "The suggestion of a high-level vocabulary so I can learn them."

Seventh, real-time interactions with AI were preferred, as stated in a comment, "It would be nice to be able to ask questions and get some sort of response."

Last, the option of connecting with a 24/7 online human tutor was requested, as noted in the following comments: "Potentially allowing for AI to connect me to a human tutor for further assistance." and "[I'd like to] have someone in the back who can read my writing when needed. [So, I don't] fully depend on AI."

LIMITATIONS

These findings should be carefully generalized for the following reasons. The students' experiences with AI-generated feedback were limited to three AI programs: Grammarly, Packback, and SafeAssign. The students were recruited from an upper-level communication course, and its sample size was relatively small. Further research is needed for different groups of learners and other AI-based programs.

DISCUSSION

The high-performing students were positively engaged with the AI assistants and got the full benefit out of them. They became confident in expressing their ideas in writing, thanks to AI. Additionally, their overall writing skills and metacognitive skills were advanced. In particular, metacognitive skills are a key for learners to be autonomous. AI-generated attributional feedback and strategy feedback would further stimulate

students' autonomy by leading them to monitor their learning progress.

In contrast, although AI helped boost their grades in their writing, the underperforming students did not think that AI-generated feedback helped improve their overall writing skills. They also expressed their discomfort with the AI assistants. Unlike high-performing students, underperforming students usually take additional time and effort to internalize new knowledge and skills. An intuitive interface would help underperforming users quickly navigate AI-operated programs. Also, they would benefit from actionable feedback such as concrete examples, detailed explanations in plain English, strategy coaching, and supplemental exercises on their frequent errors.

Despite their different attitudes toward AI, both groups agreed that AI did not effectively promote their creativity. They pointed out that the AI-generated feedback favored a formal writing style. They wanted to have input available for creative writing and causal writing. A writing style should be appropriate for occasion, purpose, audience, genre, and discipline, but it does not need to or should not be formulaic or bland. Diversified feedback for various writing styles would unleash creativity and imagination.

Although the AI assistants provided only written feedback, all four groups, divided by their learning styles, concurred that the feedback helped enhance their writing skills, metacognitive skills, and self-confidence, but not their creativity. However, as mentioned earlier, each learner prefers a different way to process information. Different learning styles could be accommodated with built-in options for students to choose other feedback modalities such as audio, video, exercises, and written instructions. Furthermore, aligned with the Americans with Disabilities Act, this feature would promote the accessibility of learners with disabilities.

As to the impact of AI on students' writing practice, the high-performing students were satisfied with its positive effect on all five aspects of their writing skills. Also, the underperforming students found AI helpful in improving their rhetorical knowledge, knowledge of disciplinary conventions, and grammar/mechanics. Meanwhile, AI did not help enhance their content development skills and ability to use sources.

The findings imply that AI should provide additional services to assist underperforming students with these two interwoven skills. For example, good reasoning and analytical skills are critical in identifying pertinent supporting details and enriching content. These skills could be enhanced by exercising critical reading and outlining and by exercises on common fallacies. Research skills, such as the ability to locate creditable sources, could be developed by showing how to use library resources. Moreover, the underperforming students would benefit from further exercises on citations and paraphrasing. In short, AI should be intelligent enough to provide tailored feedback and relevant resources to help students strengthen their weak areas.

Interestingly, when the students were grouped by their learning styles, the mean differences between groups were not statistically significant, but there were some discrepancies. The Read/Write learners appreciated the positive impact of AI-generated feedback on all five aspects of their writing skills. On the other hand, the other three groups only acknowledged its positive impact on their knowledge of disciplinary conventions and grammar/mechanics.

Considering that the AI feedback was written, it is not a surprise that the greatest beneficiaries of written feedback were the Read/Write learners. As mentioned earlier, feedback modalities should be diversified to enhance the accessibility of learners with different learning styles.

The major challenge that the students confronted while using the AI programs was the lack of live two-way interactions with the AI assistants. Unlike dynamic interactions with human tutors or instructors, the AI-operated programs did not offer room for negotiation. Preset by an algorithm favoring a formal writing style, AI assistants could potentially discourage students' creativity by prescribing a formal writing style without their consent. Another challenge was that the heavy dependency on AI could depress the students' critical thinking skills. Critical thinking skills could be fostered by providing analytical explanations of examples rather than prescriptive feedback. Several software glitches were noted, including slow running time, ad walls, and a distracting interface. These challenges should be addressed before new features are added.

Finally, suggestions for the AI assistants were categorized into two groups: (a) personalized

feedback and (b) further assistance with content development and the use of sources. For example, the students wanted to personalize their writing by interacting and negotiating with AI in real time. They wanted AI to provide supplemental learning materials targeting their frequent errors to avoid repeating the same mistakes.

Also, they wanted AI to help them with outlining, including developing content, identifying supporting details, and structuring their writing. They wished that AI could recommend credible sources suitable for their purposes. They called for help with paraphrasing and citation to avoid plagiarism. Last, they wanted to connect with a 24/7 online human tutor for further assistance when needed. These findings affirm that feedback becomes meaningful when it is contextualized, tailored, and student-centered.

CONCLUSIONS

Feedback completes an assessment. When an assessment is aimed at screening, feedback acts as a gatekeeper and focuses on the academic weakness of students. If an assessment is aimed at student growth, feedback serves as a scaffolder by helping them maximize their achievements. AI assistants should be intelligent enough to serve students as a scaffolder.

This study confirmed that students wanted to be motivated and strategically coached to reach their benchmarks rather than being judged on their performance or being dictated to by an algorithm. In other words, AI-generated feedback becomes meaningful when it is personalized to meet students' needs and to help in developing a sense of ownership of their learning (i.e., writing).

REFERENCES

AACU. (2009). Written communication VALUE rubric. https://www.aacu.org/value/rubrics/written-communication

Blackboard Inc. (2022). Blackboard SafeAssign: A plagiarism prevention tool.

https://www.blackboard.com/teaching-learning/learning-management/safe-assign

Budge, K. (2011). A desire for the personal: Student perceptions of electronic feedback. International Journal of Teaching and Learning in Higher Education, 23(3), 342–349.

Chong, S. W. (2019). College student's perception of e-feedback: A grounded theory perspective. Assessment & Evaluation in Higher Education, 44(7), 1090–1105. https://doi.org/10.1080/02602938.2019.1572067

Cox, S., Black, J., Heney, J., & Keith, M. (2015). Promoting teacher presence: Strategies for effective and efficient feedback to student writing online. Teaching English in the Two-Year College, 42(4), 376–391.

Deci, E. L., & Ryan, R. M. (2002). Handbook of self-determination research. University of Rochester Press.

Delante, N. L. (2017). Perceived impact of online written feedback on student's writing and learning: A reflection. Reflective Practice, 18(6), 772–804. https://doi.org/10.1080/14623943.2017.1351351

Ene, E., & Upton, T. A. (2018). Synchronous and asynchronous teacher electronic feedback and learner uptake in ESL composition. Journal of Second Language Writing, 41, 1–13. https://doi.org/10.1016/j.jslw.2018.05.005

Farrell, E., & Jensen, J. (2000). Rhetoric and research on class size. In R. Indrisano & J. Squire, (Eds.), Perspectives on writing: Research, theory, and practice (pp. 307–325). International Reading Association.

Fleming, N., & Mills, C. (1992). Not another inventory, rather a catalyst for reflection. To Improve the Academy, 11(1), 137–144. https://doi.org/10.1002/j.2334-4822.1992.tb00213.x

Grammarly Inc., (2020). The Grammarly editor: New look, more suggestions, better writing. https://www.grammarly.com/blog/better-writing-with-grammarly/

Jonassen, D., Spector, M., Driscoll, M., Merrill, D., Van Merrienboer, J., & Driscoll, M. (2008). Handbook of research on educational communications and technology (3rd ed.). Routledge.

Li, K. C., & Wong, B. T., (2021). Features and trends of personalized learning: A review of journal publications from 2001 to 2018. Interactive Learning Environments, 29(2), 182–195. https://doi.org/10.1080/10494820.2020.1811735

Mulliner, E., & Tucker, M. (2017). Feedback on feedback practice: Perceptions of students and academics. Assessment & Evaluation in Higher Education, 42(2), 266–288. https://doi.org/10.1080/02602938.2015.1103365

National Council of Teachers of English. (2015). Principles for the postsecondary teaching of writing. Conference on College Composition and Communication. https://cccc.ncte.org/cccc/resources/positions/postsecondarywriting#principle5

Nilsson, N. (2009). The quest for artificial intelligence. Cambridge University Press. https://ai.stanford.edu/~nilsson/QAI/qai.pdf

Packback Inc. (2022). Packback. https://www.packback.co/

Page, E. B. (1967). Statistical and linguistic strategies in the computer grading of essays. COLING '67: Proceedings of the 1967 conference on Computational linguistics. https://doi.org/10.3115/991566.991598

Press, G. (2016, December 30). A very short history of artificial intelligence (AI). Forbes. https://www.forbes.com/sites/gilpress/2016/12/30/a-very-short-history-of-artificial-intelligence-ai/?sh=69ae39056fba

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. American Psychologist, 55, 68–78. https://doi.org/10.1037/0003-066X.55.1.68

Scandura, J. (2018). A deterministic AI foundation for modeling human tutors: Fundamental assumptions in structural learning theory. Technology, Instruction, Cognition and Learning, 11, 73–112.

Schunk, D., Meece, J., & Pintrich, P. (2014). Motivation in education: Theory, research, and applications (4th ed.). Pearson.

Srivastava, K., Dhanda, N., & Shrivastava, A. (2020). An analysis of automated essay grading systems. International Journal of Recent Technology and Engineering, 8(6), 5436–5441. https://doi.org/10.35940/ijrte.F9938.038620

Sternberg, R. (2005). Intelligence, competence, and expertise. In A. Elliot & C. Dweck (Eds.), Handbook of competence and motivation (pp. 15–30). Guilford Press.

VARK Learn Limited. (2022). VARK: A guide to learning styles. http://vark-learn.com/

World Economic Forum. (2018). The future of jobs report 2018. https://www.weforum.org/reports/the-future-of-jobs-report-2018

Yu, E. (2020). Student-inspired optimal design of online learning for Generation Z, Journal of Educators Online, 17(1). https://www.thejeo.com/archive/2020_17_1/yu