

**Evaluating the Impact of Real-Time AI Feedback on Student Writing: Randomized
Control Trial**

George Hanshaw, Psy.D., (Corresponding author) ghanshaw@lapu.edu

ORDIC 0000-0002-5986-3965

Los Angeles Pacific University, Digital Learning Solutions, San Dimas, CA, USA

Kenna Norman, MBA

Los Angeles Pacific University, Digital Learning Solutions, San Dimas, CA, USA

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Abstract

This study investigates the effectiveness of real-time generative AI feedback in improving student writing compared to traditional summative feedback. Conducted over two semesters with 135 participants in ENGL 101 and 105 at Los Angeles Pacific University, the study employed a randomized controlled trial. The treatment group received real-time feedback via Grammarly, while the control group used summative methods. Key metrics included GPA, tool usage frequency, and intrinsic motivation, measured by a modified MSLQ. Results showed the treatment group achieved a significantly higher GPA (3.318 vs. 2.199), increased tool usage, and slightly higher intrinsic motivation. These findings highlight the potential of real-time AI feedback to enhance academic performance and engagement, emphasizing the importance of seamless AI tool integration in education.

Keywords: Generative AI, AI in Writing, Feedback, real-time Feedback, AI Feedback

Evaluating the Impact of Real-Time AI Feedback on Student Writing: Randomized Control Trial

We evaluated the effectiveness of real-time Artificial Intelligence (AI) feedback given during the writing process compared to traditional summative feedback in online undergraduate English courses geared towards adult learners. We measured effectiveness by comparing the final class grade point average (GPA), the extent of tool usage, and the students' intrinsic motivation to learn between the treatment and control groups. Each instructor taught both the treatment and control groups of the same course during the same term. Utilizing the same instructor for the treatment and control group was done to minimize interrater reliability issues.

The proliferation of generative AI feedback tools and the subsequent difficulty in making data-driven decisions about ed tech tools, in general, are the primary drivers for this study, which explores the use of real-time generative AI feedback in contrast to traditional summative feedback provided after the completion of a part or the entire writing process. See et al. (2022) argue for the need for more rigorous evidence of the effectiveness of specific AI tools to support evidence-based decision-making in schools and organizations. The rising costs and increased investments in these AI tools underscore the need for more rigorous evidence of their effectiveness.

Our study, which focused on the efficacy of Grammarly's generative AI in providing real-time feedback, is particularly relevant in the context of contemporary educational theories. We explored how generative AI can enhance student learning outcomes as a feedback agent within a larger system. This aligns with current educational theories, making our findings timely and applicable.

It is important to emphasize that the generative AI used was strictly limited to providing feedback and suggestions. The generative AI acted as a real-time coach, asking questions and guiding learners to their own conclusions. This approach, similar to that of a well-trained writing coach, ensured that the software was not prescriptive or completing the writing for the student, thereby maintaining the ethical use of AI in education.

In this study, we engaged four instructors across two foundational English courses: ENGL 101 (Introduction to Composition) and ENGL 105 (Introduction to Academic Research and Writing). The courses were online, asynchronous and designed to meet the needs of adult learners. We conducted the study over two semesters, Fall 2023 and Spring 2024, with both control and treatment groups present in each course. Each instructor taught one control and one treatment class in either ENGL 101 or ENGL 105. We provided the treatment group access to a "Pro" Grammarly account and instructed them to use it throughout the course. We directed the control group to utilize the summative feedback features of Tutor.com. We kept all other variables constant throughout the study.

Literature Review

Technology tools for feedback and learning are proliferating at a high rate. See et al. (2022) conducted a systematic review of the empirical research to explore the effectiveness of educational technology in supporting formative assessment. The high proliferation rate of these educational technology (ed-tech) tools makes it increasingly difficult to make data-driven decisions on which tools to invest in. Their research found that many school systems make significant investments in ed-tech without evidence supporting the decision resulting in underperformance of low impact to student outcomes.

For example, offering home computers to disadvantaged youth has no clear evidence supporting that using technology alone increases student outcomes, thus leaving districts with a significant financial investment without seeing correlated benefits.

While the challenges of implementing educational technology effectively are evident, research has also highlighted the potential benefits of using technology to provide immediate and personalized feedback to students, which is crucial for enhancing learning outcomes. Several studies and a meta analysis have found evidence to support using immediate and specific student feedback (Fan, 2023; Wan & Chen, 2023; Zhai & Ma, 2022; Strobl et al. 2019; Ranalli, 2018). See et al. (2022) also noted that providing such feedback to all students is a significant challenge. This issue can be mitigated through the use of classroom technology. As Allen et al. (2016) stated, there is technology that can adapt and differentiate content that is from a revision. By being able to differentiate between the original version submitted and a revision submitted feedback can be focused on the changes and updates made. This ability makes the feedback more personalized because the AI tool acknowledges the new content and effort put in by the student.

Ericsson et al. (1993) posited that deliberate practice was critical to achieving expert performance. They also stated that continuous feedback was crucial for deliberate practice and further skill development. Similarly, writing, being a skill, also requires continuous feedback for improvement. Castillos-Martinez and Ramirez-Montoya's (2021) research further supports this concept with their finding that feedback is a crucial aspect of increasing academic writing skills. Their research also revealed that specific, targeted feedback significantly improves a student's academic writing.

Students participating in entry-level English writing courses such as ENGL 101 and ENGL 105, which this study used, stand to gain more from feedback and deliberate practice. Young et al. (2021) found that students benefit differently from deliberate practice. Variables, such as the level of expertise prior to participating in deliberate practice, influence its effectiveness. Continual feedback in lower-level English writing courses aligns with Anders Ericsson's theory of deliberate practice, as writing is a skill that strengthens through such methods.

Moreover, Strobl et al. (2019) found that

Automated support for revising on the micro-level targeting factual knowledge (e.g., grammar, spelling, word frequencies) is well represented, whereas tools that support the development of writing strategies and encourage self-monitoring to improve macro-level text quality (e.g., argumentative structure, rhetorical moves) are infrequent. (p. 1)

which further contributes to challenges for students seeking immediate and adaptive feedback. Additionally, Allen et al. (2016) have found that automated tools that can provide feedback on student revisions are especially helpful in the writing process and can highlight how a student's writing has evolved through the completion of revisions and drafts.

The supporting evidence and identified challenges justify this study's exploration of real-time feedback using Grammarly's generative AI. This study hopes to add to a larger, more rigorous body of evidence for justifying the use of technology tools to help achieve better student outcomes and learning experiences as evidenced by better average

course grades, use of the AI tool, and growth of individual students' intrinsic motivation to learn.

There is abundant literature on the effectiveness of feedback on student outcomes (Yang et al., 2021; Vattoy & Gamlen, 2020; William, 2018; Hattie & Timperley, 2007; Kluger & DeNisi, 1997). Feedback is an integral part of each student's learning and learning experience. According to the definition posited below, feedback requires multiple agents, including but not limited to generative AI and the instructor.

Detailed and specific feedback from instructors and professors remains necessary, even with the use of generative AI. In fact, it underscores the importance of their role in the feedback process. The use of generative AI in the classroom requires instructors and professors to adjust their perspectives, but it also highlights their value and integral role in the learning process as feedback agents in this new era of generative AI (Kleijn, 2023; Gan et al., 2021; Yang et al., 2021).

Feedback is part of a more extensive support system that wraps around and supports students in their academic journey. Using generative AI as a feedback agent adds another layer to support the student.

Definition of Feedback

Formative and summative feedback serve distinct yet complementary roles in education, each offering unique insights into the learning process. Formative feedback is a continuous, often informal process that occurs during instruction. It aims to improve both teaching and student performance by providing actionable insights into specific areas for improvement. According to Baht and Bhat (2019), formative assessments help both students and teachers identify weaknesses and adjust accordingly, making it a key

tool in enhancing the learning process throughout a course (Baht & Bhat, 2019). The iterative nature of formative feedback fosters a cycle of improvement, where feedback informs students on how to improve their understanding before reaching the final assessment stages (Black et al., 2003).

Conversely, summative feedback occurs at the conclusion of a unit or course and serves a more evaluative role. It provides a formal measure of student achievement against predetermined criteria, often in the form of exams or final projects (Baht & Bhat, 2019). While summative assessments are critical for certifying what students have learned, they lack the immediate feedback loop that formative assessments offer. However, when used in conjunction, formative feedback can guide students toward success in summative evaluations, helping them refine their skills and understanding in a more holistic manner (Sadler, 1998). Together, these two feedback forms create a comprehensive picture of student learning, encouraging both immediate improvement and long-term academic growth.

For the purpose of this study, it is important to define feedback and its role in the learning process clearly. The concept of feedback has evolved in tandem with our growing understanding of its role and impact in various contexts.. Within education, the definition of feedback has gone through several iterations, moving it far from the original definition taken from industry, where feedback was information looped back into a system (William, 2018). This approach aligned with the behaviorist perspective at the time.

The next iteration happened due to the advent of cognitive and constructivist theories. This iteration effectively shifted the focus of feedback from changing a student's

behavior to helping them process and construct knowledge. This iteration moved feedback from behavioral reinforcement to an opportunity for greater learning (Sadler, 1989).

The next iteration occurred in the 1990s with new learning theories that integrated cognitive models into the concept of feedback. Kluger and DeNisi (1996) focused on cognitive processes central to feedback processing and its impact on the student. This was significant because Kluger and DeNisi (1996) found that research between 1905 and 1995 did not explore how feedback affected the student or their learning.

In more recent models, the learner is positioned at the center of the feedback process and as an active agent who processes, responds to, and generates feedback. This approach acknowledges the role of self-feedback and peer feedback, reflecting a deeper understanding of how students engage with feedback (Shute, 2008; Stobart, 2018).

With the acknowledgment of multiple agents, we can modify the definition posited by Hattie and Timperley (2007), which define *feedback* as "conceptualized as information provided by an agent (e.g., teacher, peer, book, parent, self, experience) regarding aspects of one's performance or understanding." (p. 81). Adding generative AI as an agent to the definition allows us to think of feedback as being utilized in real-time, specifically within the writing process. The authors posit that adding generative AI to the list of agents that provide feedback effectively moves the learner deeper into the center of the feedback process and facilitates active learning as the learner engages with the process.

The definition posited by the authors is that feedback is a dynamic interactive process that contains actionable, critical, and constructive information provided by an

agent that engages the learner in reflective or critical thinking. This process facilitates active learning and self-assessment, empowering learners to actively shape their learning experience.

The above-stated definition posited by the authors emphasizes the interactive nature of feedback, the role of self-assessment, and the goal of bridging the gap between actual and desired learning states, which aligns with the contemporary educational theory of constructivism and the concepts of active learning and metacognition within the realm of constructivism.

The Constructivist philosophy emphasizes active learning and facilitating people to construct their new understanding from their experiences and prior knowledge.

Grubaugh et al. (2023) stated,

Constructivism and AI share common ground in their focus on active knowledge building, adaptive support, metacognitive development, and conceptual change. Thoughtfully designed and ethically vigilant integration of AI into constructivist pedagogy can potentiate more engaging, personalized, and transformative learning aligned with enduring humanistic imperatives.” (p. 83).

The real-time AI feedback gives students the opportunity to actively engage with and build on their ability to write in an academic environment.

Generative AI as a Feedback Agent

Artificial intelligence has existed for many years for the scoring and rendering of feedback on high-stakes written tests through Automated Written Evaluation (AWE) software (Stevenson & Phakti, 2013). Stevenson and Phakti (2013) pointed out that there was fear and skepticism around using AI for feedback, "On the other hand, the notion that

computers are capable of providing effective writing feedback has aroused considerable suspicion, perhaps fueled by the fearful specter of a world in which machines replace humans.” (p. 52). With the recent proliferation of generative AI tools available for public use, skepticism and fear are replaced by curiosity and rigorous study.

While a deep dive into how generative AI works is beyond the scope of this paper, it is important to highlight the basic components that are used in today's systems to create smart feedback systems that can give real-time feedback to students. Think of the generative AI tools as an extremely sophisticated calculator for words. Generative AI uses Natural Language Processing (NLP) and Natural Language Generation (NLG) to give feedback on people’s writing. Machine learning (ML) is used within these systems to recognize patterns and make suggestions and predictions. Taulli (2019) states that NLPs are trained on a vast range of training data, such as grammar rules, and the NLP systems are also trained to recognize patterns.

The NLG is a machine-learning model with the ability to create human-like text. This and the vast training in languages is what makes the generative AI writing feedback different and more adaptable than many AWE systems. Steiss et al. (2023) utilized ChatGPT to study the differences between human and AI feedback. They found:

- Human evaluators provided higher quality feedback than ChatGPT in four out of five categories: clarity of directions for improvement, accuracy, prioritization of essential features, and supportive tone.
- ChatGPT outperformed human evaluators in providing criteria-based feedback.

- Overall, ChatGPT's feedback quality was close to that of human evaluators despite requiring no specific training for the task.

One critical piece of the findings by Steiss et al. (2023) is that ChatGPT did not have any specific training for the task. In more recent years, educational institutions have begun to adopt course and writing assistants that can be directly modified and trained by the end users to give feedback with a certain persona. This means that course assistants, such as those offered by Nectir.ai, can be taught to give feedback in the way a professor tends to give feedback. The feedback will mimic the professor's style and written mannerisms.

Great strides have occurred within the realm of artificial intelligence. Specifically, feedback from generative AI tools has become a preferred method of feedback by students. A recent study by Wan and Chen (2023) found that students rated AI-generated feedback as more valuable than human feedback, requiring only minor modifications to the feedback. These findings do not contradict the finding by Steiss et al. (2023) because Wan and Chen (2023) study highlighted the student perspective, and Steiss viewed the effectiveness of the tool from an educator's perspective. This finding suggests that AI-generated feedback is comparable to human feedback in terms of accuracy. The most startling finding in the study is that students consistently rated the AI-generated feedback as more useful because of its length and specificity.

In exploring the role of Generative AI as a feedback agent, recent studies have explored its potential in terms of accuracy, acceptance, and preference over human feedback. There are instances when generative AI feedback as an agent is not fully helpful or preferred. Fan (2023) found within their study on automated written corrective

feedback (AWCF) that English as a Foreign Language (EFL) students were mixed in their feelings and satisfaction towards the feedback given from Grammarly. Some found AWCF helpful for writing mechanics, while others criticized its lack of social learning aspects and specific, meaningful error correction.

Ranalli (2018) explored how well students utilize AWCF, considering factors like feedback explicitness, the need to evaluate the accuracy of automated error flagging, and the absence of individualized responses in AWCF systems. Much like the findings of Wan and Chen (2023), the explicitness of the feedback significantly influences students' ability to use AWCF effectively. Ranalli (2018) found that specific feedback resulted in more successful error corrections than generic feedback and that students found the specific feedback less mentally taxing.

AI can be used as a feedback method in a variety of ways. AI tools are able to process, analyze, and deliver specific feedback on prompts, questions, and completed assignments much more quickly than a human is able. However, AI tools are somewhat limited in that they may not be as accurate as a human in delivering feedback, and if not given specific parameters or enough information in the entry, they may not be as effective. Steiss et al. (2023) found that human feedback is more consistent and better as the level of difficulty increases within an essay. The benefits of AI tools seem to outweigh the negatives solely based upon speed and specificity. In our research, we will gauge the overall student experience with real-time formative feedback from AI, compared to summative feedback from humans.

Shackel (2023) explores the students' perceptions and how well they utilize feedback from a university writing center. The positive findings of Shackel (2023)

support the findings of Wan and Chen (2023), Fan (2023), and Ranalli (2018). The similarity in the findings of the literature is that students are better able to utilize feedback when it is explicit and detailed. Vague or generic feedback is difficult for students to utilize. The AI-generated feedback was regularly seen as more explicit and detailed than the human feedback.

The findings by Wan and Chen (2023), Fan (2023), Shackel (2023), Steiss (2023), and Ranalli (2018) support the use of generative AI feedback because it is very close to human feedback and can be more easily scaled to meet the significant demands that a large course enrollment may pose. Shackel (2023) also found that students with dyslexia find that feedback from generative AI allows more time for reflection and processing, thus helping to close the education gap for students with disabilities.

Purpose and Hypothesis

The purpose of this study was to examine the effects of student use of real-time AI feedback given during the writing process in 100-level English courses compared to summative feedback given at the end of the writing process from humans. The real-time AI writing assistant utilized for this study is Grammarly.

There are three specific items within the study that are of interest: class GPA, amount of tool use, and intrinsic motivation to learn of the student. The assignment instructions directed the control group to utilize and receive feedback from a human tutor the treatment group used Grammarly throughout the writing process (prewriting, editing, and finalizing). Both groups received a grade and summative feedback from their instructor.

In these English courses, students produced two essays: an illustrative essay and a persuasive essay in Engl 101, and a reading response and an argumentative essay in Engl 105. The assignments are broken into parts, where the student compose an essay draft, submit the draft for feedback, make revisions, and then resubmit the essay for a final grade. Appendix B is the instructions for part 2 of the illustrative essay for the treatment group, and Appendix C is the instructions for part 2 of the illustrative essay for the control group.

- $H_{01(Alt)}$: Students in 100-level English courses who use real-time AI feedback during the writing process achieve higher grades than those who receive post-writing feedback from AI or human sources.
- $H_{02(Alt)}$: Students in 100-level English courses who utilize real-time AI feedback and writing assistance during the writing process utilize the service more than a feedback intervention sought out after the writing process is complete.
- $H_{03(Alt)}$: Students in 100-level English courses who utilize real-time AI feedback and writing assistance during the writing process build a stronger sense of intrinsic motivation.

Method

Research Design

This study employed a randomized controlled trial (RCT) with a between-subjects design to evaluate the effects of real-time artificial intelligence (AI) formative feedback on a student's writing within 100-level English courses compared to summative based human feedback. The RCT approach was utilized because it is considered to be the most valued research methodology for examining the efficacy or effectiveness of interventions

(Houle, 2015). This study utilized multiple factors to evaluate the effectiveness of the intervention in order to help identify a more holistic view of the student experience with AI technology. Course GPA and Tool use were quantitatively measured. The student's intrinsic motivation to learn was measured using a modified MSLQ survey (see Appendix A) with a Likert scale.

Two trials were conducted over two terms: the first in Fall 2023 and the second in Spring 2024. Each session lasted eight weeks. The courses utilized in the study were asynchronous online courses. The control group had access to and instructions for using feedback from human tutors. The treatment group had access to Grammarly Pro and the real-time AI feedback it provides. The feedback from Grammarly Pro was immediate and it provided contextual and specific feedback. Students were able to ask Grammarly Pro to review and assess the paper as well.

Participants were randomly assigned to either the control or treatment groups by the course registration system, ensuring comparability between groups and enhancing the internal validity of the findings. Multiple hypotheses were formulated and tested to address the research questions.

Two 100-level online courses were chosen for the study: ENGL 101 and 105. The courses were taught online, and the content was the same for both, except for the addition of requirements for the use of Grammarly in the assignment instructions for the treatment group. Students in the treatment group received a free premium Grammarly account. The same instructor taught the control and treatment courses, which ensured interrater reliability.

- Instructor 1: taught ENGL 101 control and ENGL 101 treatment in the Fall term.

- Instructor 2: taught ENGL 105 control and ENGL 105 treatment in the Fall term.
- Instructor 3: taught ENGL 101 control and ENGL 101 treatment in the Spring term.
- Instructor 4: taught ENGL 105 control and ENGL 105 treatment in the Spring term.

Materials

Independent Variable.

The type of feedback is the independent variable. The treatment group utilized real-time AI feedback provided through Grammarly. The control group utilized human feedback provided by a human tutor.

Dependent Variable.

There were three dependent variables investigated within this study.

- Class GPA: This refers to the average grade for the course, calculated using a typical 4.0 GPA scale. This was a direct calculation of the final grade results for each of the courses.
- Tool usage: The number of times a student utilized either Grammarly or Tutor.com tools. Both of these tools provided the number of times students accessed the tools via a report that was created to count only the number of times the participants in the course accessed the specific tool.
- Intrinsic motivation: The level of intrinsic motivation to learn, as measured by a modified Motivated Strategies for Learning Questionnaire (MSLQ). The survey was delivered during week 7 of the 8 week course. Week 7 was chosen so it

would not interfere with the End of Course Survey that is sent to students in the final week.

Instruments and Tools

Two separate feedback tools were used for the control and treatment groups. The treatment group used Grammarly and received real-time AI feedback on their writing. The control group had access to human tutors on demand or by appointment.

Real-time Feedback Tool

Grammarly is a generative AI tool that analyzes the writing habits of the writer and provides recommendations in real-time. These recommendations range from styling assistance (MLA, APA, Chicago, etc.) to clarity, grammar, and nuances such as tone and diction. These recommendations are AI-generated as the writer composes their work and aims to improve their approach and process.

Unlike other generative AI tools, Grammarly does not compose the writing for the student; rather, it offers suggestions for revisions and improvement based on the context and content provided. The writer can also use Grammarly as a brainstorming tool to organize and enrich their writing. The brainstorming aspect is helpful to get students started in the writing process. There are a variety of settings that can be customized to fit the writer's needs, such as the tone of writing (academic, casual, business communication, etc.), the purpose of writing, and other specific goals of the writer.

Summative Feedback Tool

Tutor.com was utilized because it offers human feedback for writing. Tutors were available on-demand or by appointment. The feedback from the human tutors was given

at the completion of the writing process and before the student submitted their paper for grading. The general feedback process was:

- Initial Review: The tutor reviews the submitted essay, identifying key areas that need improvement.
- Interactive Session: In a live session, the tutor engages the student in a discussion about the essay, addressing specific questions and concerns raised by the student.
- Detailed Feedback: The tutor provides comprehensive feedback, covering grammar, punctuation, sentence structure, and overall organization of the essay. This feedback can be given during the live session or through written comments if the paper is submitted for review outside of a live session.

The tutors are highly qualified as evidenced by passing subject exams and background checks.

Motivated Strategies for Learning Questionnaire (MSLQ)

The MSLQ is a thoroughly validated tool to measure a college student's intrinsic motivation to learn, among other criteria (Artino, 2005; Pintrich et al., 1993). The survey has been used and adapted by universities across the world. We chose to adapt the MSLQ to a 5-point scale due to students being more familiar with the 5-point scale and to adapt the questions for the online environment. See Appendix A.

Data was collected for the MSLQ with our electronic survey tool. The survey was sent to all students in the control and treatment groups through email and a pop-up message directly in the LMS.

H01 Course GPA

A comparison of overall course GPAs between the control and treatment groups was conducted. An unpaired t-test was used to compare the results of the two independent samples.

H02 Utilization

A comparison of the amount of use between real-time AI feedback and the summative feedback service. The distribution of the data determined the test used to compare the groups. The Welch's t-test was chosen because there are unequal variances and sample sizes between the two data sets.

H03 Intrinsic Motivation

A comparison of the sense of intrinsic motivation between the control and treatment groups. Intrinsic motivation was measured in the seventh week of the 8-week course, so the survey was not confused with the standard end-of-course survey. A modified Motivated Strategies for Learning Questionnaire (MSLQ) was used. The data is ordinal data from the Likert rating. The Mann-Whitney U test was utilized to test the responses from the MSLQ survey because the assumptions of the t-test were not met.

Measures

We utilized the process outlined below to compare the treatment and control group in each category. The steps were as follows.

1. Perform the Shapiro-Wilk test to test for normal distribution.
2. Results found to be normally distributed followed this process. :
 - a. Perform an Independent Samples t-test.

- b. Perform permutation testing to determine if the results from the independent samples t-test are supported, thus eliminating any errors due to sample size. Permutation testing provides a more exact p-value as well.
- 3. Results found to not follow a normal distribution followed this process:
 - a. Perform Mann Whitney U test to test differences.
 - b. Perform permutation testing to determine the precise p-value.
 - Permutation tests do not assume any specific distribution.
- 4. Effect size testing
 - a. Perform Cliff's d
 - b. Perform Cohen's d

This process was applied to the outcomes of the grades, overall percentage scores, self-efficacy, intrinsic motivation to learn and the feelings of engagement, support, and encouragement.

Participants

Participants were university students at Los Angeles Pacific University enrolled in either English 101: Introduction to Composition or English 105: Introduction to Academic Research and Writing in the Fall 2023 or Spring 2024 semesters. The age of the participants ranged from 18 to 56, with a mean age of 36.8125 and a median age of 36.5. The sample was predominantly female (71%). In terms of ethnicity, the sample was diverse with 48% identifying as Hispanic, 24% as White, 19% as African American, and 7% as Asian. The demographic composition of the participants closely mirrored the

overall student demographics at Los Angeles Pacific University, providing a representative sample for the study.

Students within the course were invited to access Grammarly Pro through an announcement in the course by the LMS administrator. Students in the control group received a Grammarly pro account for the term, whether they opted into the survey or not. Those who opted in and completed the survey first completed an electronic informed consent approved by the university's IRB.

The students in the treatment group received access to Grammarly Pro. The treatment group was instructed to use Grammarly for each writing assignment and instructed on how to use it from an ethical perspective. Instructors were also equipped with tools to support students in their use of Grammarly. The assignment instructions were the same for the control and treatment groups, with the exception of adding the use of Grammarly and removing the use of Tutor.com from the treatment group instructions. See Appendices B and C for a comparison of assignment instructions.

The study involved a total of 135 participants. Only 64 of the participants completed both the end-of-course and study surveys. The survey completion rate for this study was 47.4% which aligns with the typical survey completion rates for courses at the university.

Data Collection

Inclusion and Exclusion Criteria

This study intended to compare the effectiveness of real-time AI-generated feedback when compared to summative feedback given by a human in influencing academic outcomes such as grades, system use, and intrinsic motivation. To ensure the

integrity and clarity of our research, we defined the inclusion and exclusion criteria for participant selection. These criteria are pivotal in distinguishing the treatment group (those who used Grammarly) from the control group (those who did not use Grammarly, but may have used Tutor.com).

The criteria for data inclusion in this study were derived from student responses to a structured survey and their participation in either the control or treatment groups. This survey was administered during the seventh week of an eight-week course. This timing was selected to avoid conflicts with the university's standard end-of-course evaluations. It was deemed that using the seventh week was acceptable to ensure students had adequate exposure to the course content and tools under investigation, thereby providing informed responses. Following the administration of the survey, a data cleaning and validation process was conducted. This process was guided by the predefined criteria detailed below, aimed at ensuring the integrity and relevance of the data for subsequent analysis.

Treatment Group Data Set

Students who stated that they utilized Grammarly as part of the study and were part of the treatment group were included in the factoring of scores and outcomes in the treatment group. Student data was included in the analysis of the results based on the following criteria:

Inclusion criteria:

- Enrollment and Participation: The participant must have been enrolled in and actively participated in the control course during the study period.
- Use of Grammarly: The participant must have consistently utilized Grammarly as a part of their coursework in the control course.

- Non-use of Tutor.com: The participant did not engage with Tutor.com for any academic assistance during the course of the study.

Exclusion criteria:

- Non-use of Grammarly: Participants who did not use Grammarly during the study period were excluded.
- Use of Tutor.com: Any engagement with Tutor.com services led to exclusion from the treatment group, as it could confound the effects attributed solely to Grammarly.

Survey data from students who did not meet the inclusion criteria was not utilized for the study.

By adhering to these criteria, our study aimed to provide a robust and fair comparison between real-time feedback and coaching compared to summative coaching and feedback.

Control Group Data Set

The inclusion and exclusion criteria for the control group were designed to help remove any results bias, such as students using a personal Grammarly account while participating in the control group course. Students who did not use Grammarly and were part of the control group were included in the factoring of scores and outcomes in the control group. Student data was included in the analysis of the results based on the following criteria:

Inclusion criteria:

- Part of the control course.

- Did not use Grammarly. Some students may have had a personal Grammarly account. If they are in the control group and use Grammarly, they are excluded.
- Had the opportunity to use Tutor.com.

Exclusion criteria:

- Utilized Grammarly for their assignments.

Data Availability

Public Data is located here:

<https://drive.google.com/drive/folders/1eKTPN6cy2LCilgYEbW8Z0-F8m0RBTYw8?usp=sharing>

Results

Course GPA (H01)

The GPA results included 55 students in the treatment group and 77 students in the control group. The treatment group received real-time AI writing feedback, while the control group received summative feedback. The analysis showed a significantly higher mean GPA in the treatment group (3.318) compared to the control group (2.199), with a p-value of 0.0001 and a large effect size ($d = 0.765$). The alternate hypothesis is supported. We can reject the null hypothesis. See Table 1 for details.

Table 1. Overall Results

Group	N	Mean GPA	SD	P-Value	Effect Size
Treatment	57	3.318	0.992	0.0001	0.765
Control	78	2.199	1.815		

Normality Tests

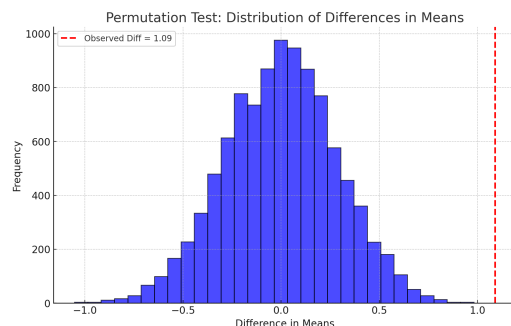
The results of our study indicate that the data for both groups were not normally distributed based on the Shapiro-Wilk test results ($W = 0.733, p < 0.000001$ for the treatment group; $W = 0.738, p < 0.000001$ for the control group). Because the results did not follow a normal distribution we utilized the permutation test to test for the significance in differences of the observed means.

Permutation Test

A permutation test with 10,000 permutations was performed to assess the significance of the observed difference in means. The observed difference in means was compared against the distribution of differences generated through permutations. The permutation p-value was 0.0001, indicating a statistically significant difference between the treatment and control groups.

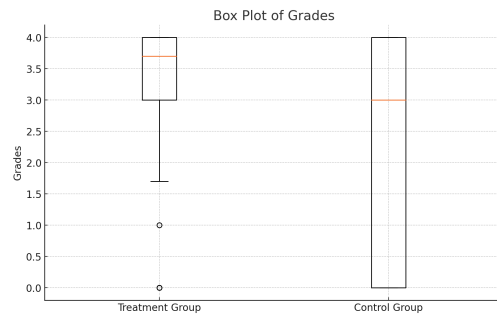
Figure 1 shows the histogram of permutation differences, with the observed difference indicated by the dashed line.

Fig. 1 Histogram



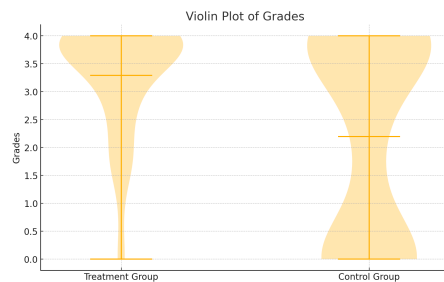
The box plot (Figure 2) compares the GPA distributions for the treatment and control groups, highlighting the central tendency and variability.

Fig. 2 Box Plot



The violin plot (Figure 3) provides a detailed view of the data distribution, combining aspects of both box plots and density plots.

Fig. 3 Violin Plot



Effect Size

Effect size was measured using both Cohen's d and Cliff's Delta:

- **Cohen's d :** 0.719, indicating a medium to large effect size.
- **Cliff's Delta:** 0.262, indicating a small to medium effect size.

The alternate hypothesis is supported. We can reject the null hypothesis. Students who utilized real-time AI feedback while writing within 100-level English courses achieved higher grades than students who utilized summative feedback from a human source after writing.

ENGL 101 and ENGL 105 Use of Service (H02)

In both ENGL 101 and 105, the tool providing real-time feedback was used significantly more than the tool providing summative feedback. These match the expected results because students only had to set up Grammarly once, and it was automatically part of whatever writing tool they used. For students to receive summative feedback, they had to take action each time and submit their papers to the service. Students receiving real-time feedback and writing help did not have to take any extra steps after they accepted the software.

There was a significant difference in the average use per student. Students with access to Grammarly utilized the tool an average of 4.489 times, and students with access to human tutors accessed the tool an average of 0.286 times. The effect size was 2.785 identifying a massive effect size in terms of tool usage. See Table 2 for details.

Table 2. Number of Times Feedback Service Was Utilized

	Average number of times used per Student	Total Use	P Value	Effect Size
ENGL 101				
Treatment	6.75	615	0.0001	5.0532
Control	0.333	13		
ENGL 105				
Treatment	3.229	647	0.0001	3.0065
Control	0.235	9		
ENGL 101 & 105				
Treatment	4.489	1,262	0.0001	2.7858

Control	0.286	22		
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H03 (Intrinsic Motivation):

Normality Tests

Normality was assessed using the Shapiro-Wilk test. The results indicated that both the treatment group ($W=0.754, p<0.000001$) and the control group ($W=0.772, p<0.000001$) deviated significantly from normality, suggesting that the data were not normally distributed.

Mann-Whitney U Test

Given the non-normal distribution of the data, a Mann-Whitney U test was conducted to compare the Likert scale responses between the treatment and control groups. The results indicated a statistically significant difference between the groups ($U=45505.0, p=0.0055$).

Effect Size

Effect size was measured using both Cohen's d and Cliff's Delta:

- **Cohen's d:** 0.215, indicating a small effect size.
- **Cliff's Delta:** 0.126, indicating a small effect size.

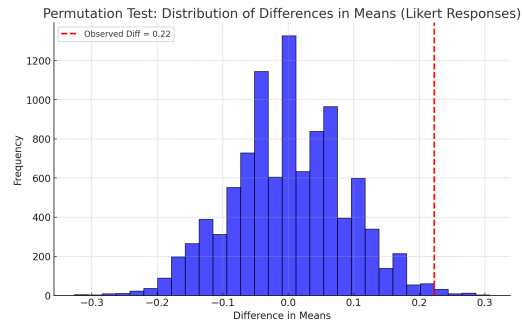
Permutation Test

To further explore the significance of the observed differences, a permutation test was performed with 10,000 permutations. The observed difference in means ($\Delta=0.215$) was compared against the distribution of differences generated through permutations. The permutation p-value was 0.0096, indicating a

statistically significant difference between the treatment and control groups at the 0.05 significance level.

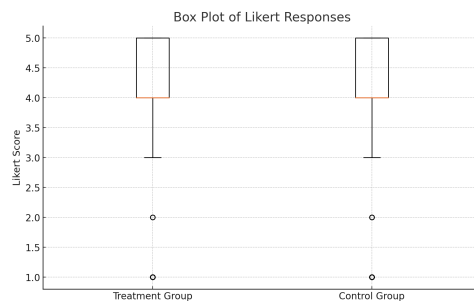
Figure 4 shows the histogram of permutation differences, with the observed difference indicated by a red dashed line.

Fig 4 Histogram of permutation differences



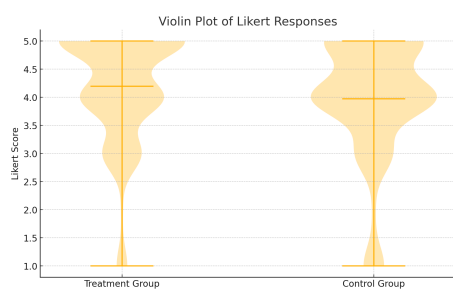
The box plot (Figure 5) compares the Likert score distributions for the treatment and control groups, highlighting the central tendency and variability.

Figure 5 box plot comparison of liker scores



The violin plot (Figure 6) provides a detailed view of the data distribution, combining aspects of both box plots and density plots.

Figure 6. Violin plot of data distribution



Discussion

The findings of this study demonstrate that real-time generative AI feedback has a significant and more holistic effect on students. Using generative AI as a real-time feedback tool can have significant effects on grades, tool use, and intrinsic motivation to learn.

Impact on Grades

Students who received real-time AI feedback achieved significantly higher grades compared to those who received summative feedback. This outcome aligns with previous research indicating that immediate, specific feedback enhances learning outcomes (Fan, 2023; Wan & Chen, 2023; Strobl et al., 2019). Real-time feedback allows students to identify and correct errors during the writing process, promoting continuous improvement and a deeper understanding of the material. This finding supports Ericsson's (1993) theory of deliberate practice, which emphasizes the importance of continuous feedback for skill development.

Intrinsic Motivation to Learn

The study also found that students receiving real-time AI feedback reported higher levels of intrinsic motivation to learn. Although the effect size was small, it indicates that real-time feedback can positively influence students' engagement and

motivation. This result is consistent with the literature suggesting that immediate, actionable feedback fosters a sense of accomplishment and encourages students to take ownership of their learning (Ranalli, 2018; Shackel, 2023).

Tool Usage

The significant difference in tool usage between the treatment and control groups underscores the convenience and accessibility of real-time AI tools like Grammarly. Students in the treatment group utilized Grammarly an average of 4.49 times, while those in the control group used summative feedback only 0.29 times on average. This disparity suggests that tools integrated seamlessly into the writing process, requiring minimal additional effort from students, are more likely to be used consistently. This finding is particularly relevant for working adult students, who may prioritize tools that optimize their time and effort.

Integrating AI in Education

The findings highlight the potential benefits of integrating generative AI tools into the educational process. AI tools like Grammarly Pro provide scalable, high-quality feedback that can enhance the learning experience without replacing the crucial role of human instructors. From a cost-benefit perspective, leveraging AI for routine feedback tasks can reduce the time and effort required from instructors, allowing them to focus on more complex, personalized interactions with students, thus maximizing educational outcomes while minimizing resource expenditure.

For online students, the integration of AI tools like Grammarly Pro offers significant advantages by providing timely and personalized feedback, which is crucial in a virtual learning environment where face-to-face interaction is limited. These tools can

help bridge the gap between students and instructors by offering immediate, detailed feedback on writing tasks, allowing students to refine their work independently before submission. Furthermore, online students often face unique challenges, such as managing their own time and navigating a more isolated learning experience. AI tools can serve as a constant support system, offering guidance and improving their skills at any time of the day, without having to wait for instructor responses. This not only enhances the learning process but also fosters self-directed learning, which is a vital skill in an online educational setting.

These findings are consistent with previous research on how generative AI can enhance learning and the learning experience (Fan, 2023; Wan & Chen, 2023; Zhai & Ma, 2022; Strobl et al., 2019; Ranalli, 2018). However, our study extends this research by showing that real-time AI feedback can increase students' grades and intrinsic motivation to learn. This broader holistic view of the student helps to hone our abilities further to create effective learning environments through the use of emerging technologies.

Limitations

Despite the promising results, this study has several limitations. The sample size was relatively small, and the study was conducted at a single institution, which may limit the generalizability of the findings. Additionally, while measures were taken to ensure random assignment, the study did not assess students' prior writing abilities, which could influence the outcomes. The self-reported nature of the intrinsic motivation survey may also introduce bias.

Future Research

With the proliferation of AI tools and technology, there are many areas for future research. The authors suggest that one rich area of research is in the area of instructor skills and attitudes toward emerging technology within the classroom. From this study, we see a possible correlation between the instructor's skills and attitudes toward technology and the effectiveness of the technology in terms of GPA. This seems to indicate that teaching with AI is different and requires specific skills and attitudes.

Future research should also explore the long-term impact of real-time AI feedback on student performance and motivation. Studies could investigate how different types of AI feedback (e.g., formative vs. summative) affect various aspects of learning across diverse educational settings. Additionally, examining the role of instructor attitudes and skills in effectively integrating AI tools into the classroom would provide valuable insights.

Teaching with AI is Different

As we look at the outcomes of the three hypotheses, it is possible to see that teaching with AI is different and requires additional skills and attitudinal perspectives to achieve the large differences in outcomes. The emerging AI tools that are readily available are powerful and can make significant differences for students. This further indicates that the instructor's attitude towards the technology directly affects its use. This thought is out of the scope of the current study but is worth investigating further.

Hanshaw and Hanshaw (2023) found that instructors who create a level of learner safety within their classroom experience overall higher GPAs in their courses. An attribute of learner safety is to learn, ask questions, and experiment with concepts and

ideas. It is worth measuring the amount of learner safety felt within the different courses to see if there is a direct correlation. Generative AI tools, like Grammarly Pro, can contribute to creating this culture of safety by providing anonymous, non-judgmental feedback. Because the feedback is automated and not delivered by a human, students may feel more comfortable experimenting with their writing and ideas, free from concerns about judgment or bias, thus fostering a safer and more supportive learning environment.

The authors posit that specific skills and attitudes toward AI technology are required to facilitate higher grades for students. This underscores the importance of not only integrating AI tools into the educational process but also ensuring that instructors are adequately prepared and receptive to technology advancements. Even if instructors are open to the new technology they must possess the necessary requisite skills to model the role of the technology within the class.

Conclusion

This study explored the impact of real-time generative AI feedback on student grade outcomes, tool use, and intrinsic motivation to learn in two separate 100-level English courses. The findings indicate a significant positive effect on grade outcomes, tool utilization, and intrinsic motivation to learn.

The results also stress the importance of integrating AI feedback tools seamlessly into the educational process. Students were more likely to utilize the real-time feedback tool, which was automatically activated during writing, as opposed to summative feedback tools that required additional steps to access. This ease of use likely contributed to the observed improvements in student outcomes.

While real-time AI feedback showed promise in enhancing intrinsic motivation, the effect size was small. This suggests that while AI feedback can contribute to motivation, it is likely more effective when used as part of a comprehensive strategy that includes other motivational elements.

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Appendix A

Modified Motivated Strategies for Learning Questionnaire

The scale used for this survey is a Likert scale from 1 – 5 with 1 being the lowest and 5 being the highest score.

1. I prefer class work that is challenging so I can learn new things.
2. It is important for me to learn what is being taught in this class.
3. I liked what I was learning in this class.
4. I liked how I learned in this class.
5. I was certain I could understand the ideas taught in this course.
6. I will be able to use what I learn in this class in other classes.
7. I expected to do very well in this class.
8. I was confident that I could do an excellent job on the problems and tasks assigned for this class.
9. I think I will receive a good grade in this class.
10. I think that what I learned in this class is useful for me to know.
11. Understanding how to write well is important to me.
12. I use what I have learned from real-time or summative feedback from past assignments to do new assignments.

Appendix B

Illustrative Essay Part 2 Instructions for Treatment Group

Treatment Group Instructions for Illustrative Essay Part 2

1. Review the feedback from your outline, and incorporate any changes necessary in this part of the assignment.

Note: Even though this is called a draft, it should be written as a completed essay, not a rough draft.

2. Download the APA Format Essay Template (opens in a new window, select "Use Template") to guide you in writing this essay.
3. Respond thoughtfully to the writing prompts below.
 - Describe this issue/problem in depth.
 - Describe the impact that it has on you/your family/community.
 - Explain the source of the problem in detail.
 - Offer a possible solution(s) to this problem based on the evidence presented earlier in the essay.
 - Describe how the issue/problem might be improved with the implementation of the solution.
4. Complete your essay using the GrammarlyGo suggestions. Use your judgment to brainstorm and accept suggestions as necessary.
5. Copy and paste the text of your essay into a new submission on Grammarly.com. Click "Overall Score" on the right panel. Review your score and the suggestions made.

- If you would like to improve your score or accept some of the suggestions, go back to your document and make the changes there. Do not make the changes in Grammarly. Then, follow the instructions to upload your document to GrammarlyGo again for an updated report.
 - If you are happy with your document, click “Download PDF Report.”
 - Take a few minutes to review your report and note areas of improvement.
6. Upload your paper and the PDF Report from Grammarly using one of the options below.
- Follow the steps in [Uploading a Google Doc as an Assignment Submission](#) (open in a new document).
 - Follow the steps in [Downloading Documents as a PDF Document](#) (open in a new document), then upload it.
7. Submit your paper and Grammarly PDF Report for feedback and grading before the deadline by following the instructions below.

Resources

- [Writing & APA Assistance](#) (open in new window)
- [Grammarly | Download PDF Report Tutorial](#)
 1. After running your paper through Grammarly's online version and after making any necessary corrections, click on "Overall Score" at the top right to open up the summary report.
 2. Click "Download PDF Report"
 3. Your report should automatically download to your computer as a PDF.

Requirements

- Word Count: 650-850 words
- Grammarly PDF Report
- APA Formatting
- Download and Submit Report from Grammarly. Use plagiarism checker in Grammarly.

Appendix C

Illustrative Essay Part 2 Instructions for Control Group

Control Group Instructions for Illustrative Essay Part 2

1. Review the feedback from your outline, and incorporate any changes necessary in this part of the assignment.
Note: Even though this is called a draft, it should be written as a completed essay, not a rough draft.
2. Download the APA Format Essay Template (opens in a new window, select "Use Template") to guide you in writing this essay.
3. Respond thoughtfully to the writing prompts below.
 - Describe this issue/problem in depth.
 - Describe the impact that it has on you/your family/community.
 - Explain the source of the problem in detail.
 - Offer a possible solution(s) to this problem based on the evidence presented earlier in the essay.
 - Describe how the issue/problem might be improved with the implementation of the solution.
4. Participate in a session with Tutor.com by using the completed draft of your paper.
5. After the Tutor.com session, at the bottom of your draft, state in either a paragraph or in bullet form the feedback that you acted on from Tutor.com to make changes to your draft.
6. Upload your document using one of the options below.

- Follow the steps in [Uploading a Google Doc as an Assignment Submission](#) (open in a new document).
 - Follow the steps in [Downloading Documents as a PDF Document](#) (open in a new document) then upload it.
7. Submit your draft for feedback and grading before the deadline by following the instructions below.

Resources

- [How to Meet with a Tutor | tutor.com](#) (open in new window)
- [Writing & APA Assistance](#) (open in new window)

Requirements

- Word Count: 650-850 words
- APA Formatting
- Plagiarism Submission