

## Effect of AI-Driven Adaptive Learning Systems on English as a Foreign Language Writing Proficiency: A Mixed-Methods Study



Zhen Li <sup>1,\*</sup>.

1, School of Foreign Languages, China Pharmaceutical University, Nanjing, 211198, Jiangsu  
China.

[lizhenenglish\\_cpu@163.com](mailto:lizhenenglish_cpu@163.com)

### Acknowledgement:

#### Funding

This work was supported by 2022 General Project of Humanities and Social Sciences of the Chinese Ministry of Education 22YJC740043.

### Abstract

This research aims to address the effects of using AI learning in enhancing EFL writing skills with the aid of both qualitative and quantitative research methodologies. The participants were 60 EFL learners, in which 30 learners used an AI-based system that provides writing feedback while 30 learners received conventional instruction. The results were quite encouraging as the experimental group improved in grammar, vocabulary, sentence constructions and cohesiveness in writing as compared to the control group. These improvements were deemed statistically significant based on the results of the paired t-tests and backed by the qualitative data gathered through interviews, which illustrated enhanced learner activity, motivation, and self-directiveness. The study also indicates that AI-based adaptive learning systems have several advantages over conventional approaches: AI delivers timely, student-specific feedback promoting greater engagement and faster mastery of writing skills. However, the study also pointed out some possible limitations of the proposed AI system where parameters such as grammatical range appeared to be overfocused at the expense of the more complex rhetorical skills as well as exploratory argumentation and creativity, which are important areas for further research. In conclusion, this research proves

significant in offering an insight into how AI technologies may help in changing the face of language learning, especially EFL writing proficiency.

## **Introduction**

The use of AI in learning environments has brought progressive changes in the curriculum delivery systems and learning experience, particularly in Foreign Languages especially EFL. One of the most laborious tasks in language acquisition, writing entails several facets, which involve grammar, lexicon, cohesion, and organization. The past EL writing has also posed challenges to the learners in their writing class effectively mainly because the teachers cannot devote much of their time in giving feedback to every learner individually (Huang, 2020). For years, mainstream classroom practices have been the cornerstone of language education (Chapelle 2003) despite their key shortcomings to meet the individual need of students; especially in writing where frequent practice, feedback, and improvement are sacrosymptoms (Graham & Perin, 2007).

The significant enhancements of the various AI technologies have enabled the creation of adaptive learning systems that can effectively address this issue. In adaptive learning systems, content, pace, and difficulty levels help the learner by using algorithms (Siemens, 2013). These systems can offer feedback and modify what is presented straight away based on the student's performance in the course. Learning language, particularly writing proficiency, can benefit from an AI-driven adaptive system which corrects the grammatical mistakes besides pointing out the appropriate use of the given vocabulary, sentence formation and coherence of the whole written data. It offers learners the opportunity to self-correct as well as correct errors as they progress, thus helping to address one of the common criticisms of conventional EFL instruction – lack of individualised feedback or one-on-one interaction with the teacher.

The potential for using AI-based adaptive learning systems for improving language proficiency is a not just a theoretical concept; the promotion of using the ai-based learning systems is backed by increasing empirical evidence that supports the effectiveness of these learning systems in contributing to the hostel students' learning outcomes particularly in the areas of reading comprehension, vocabulary and grammar (Lee et al., 2021 '.') For example, software like Grammarly or Write & Improve using artificial intelligence to suggest corrections to grammar and vocabulary within a few seconds of writing have been widely accepted by learners due to their

ability to correct their mistakes instantly and to develop their writing skills through using the resources (Kessler, 2018). However, there is still only a limited amount of studies that focus on the impact of AI-based adaptive learning systems for EFL writing skill improvement. Most of the previous works were related to either grammar or reading, and there is a lack of insight into the effects of such systems on the complex aspect of writing (Chen & Wang, 2021).

Measuring writing in EFL is a multifaceted task that is not only a concern of technical competencies like grammatical and lexical knowledge but also strategic capabilities including critical thinking, consistency, and planning (Hyland, 2003). Therefore, this research sought to investigate how AI writing assistance in adaptive learning systems enhances proficiency in the EFL writing, with specific reference to grammar, vocabulary usage, sentence construction, and coherence. At the same time, the study seeks to compare the efficiency of AI-based systems by evaluating learner motivation, self-organised learning, and engagement which are considered essential prerequisites for learning languages (Deci, & Ryan 2000).

The research can benefit in several ways: First of all, it analyses the possibilities of AI in helping to improve the foreign language writing, especially in EFL, which is still a problem area. Through studying possible approaches to increasing the performance of adaptive learning systems based on the use of artificial intelligence in writing, this paper extended the knowledge regarding the application of AI in learning practices. Second, it also solves an important research question to identify these systems' added instructional value not only to facilitate the development of students' technical writing skills but also cognitive and motivational aspects of writing in the target language. In conclusion, the conclusions of the present study may help enhance subsequent instructional design and language teaching paradigms, contributing to the progressive development of more effective language learning resources.

The use of AI technology is becoming widespread, and as a result; it is evident in learning institutions in the teaching and acquisition of language. Even though the potential of AI has been discussed regarding other aspects of education, its ability to improve writing skills in EFL is still an under researched subject. In this learning activity, the author aims to extend this discussion and make his research as an informative input to the ever-evolving discourse on language education in the age of artificial intelligence.

## **Literature Review**

Technological advancement in the form of adopting AI in language acquisition has revolutionized the conventional approaches to language learning and has the prospects to address some of the critical issues in teaching English as a Foreign Language (EFL) programs. In relation to the different elements of language acquisition, writing is the area that is considered as unfortunate, difficult, and troublesome for EFL learners. Classroom teaching as well as instructor feedback in the form of comments have been the dominant approaches to language instruction; however, there is an increasing literature that shows that the flexible intelligent systems that use AI can enhance students' writing skills. Combining theoretical and empirical resources, this literature review aims to first introduce the three forms of AI-based adaptive learning systems and secondly, to review the various outcomes of research investigating its impact on EFL writing proficiency.

### **The Role of AI in Language Learning**

Educational application of artificial intelligence has been a focus of much discussion in the last decades given the development of learning algorithms and data analysis that made it possible to develop intelligent Tutoring systems, language type technologies and adaptive learning platforms (Choi & Lee, 2020). AI is capable of diagnosing student performance and offering feedback, I believe that the results of the use of AI in personalizing contents based on the learner's needs is highly commendable. In the context of EFL, it is possible to observe that some aids in language learning, often relying on artificial intelligence technologies, like voice recognition systems, grammar checkers, and individualized writing platforms are widely used nowadays (Yin, 2021). These are artificial learning tools that mimic human interaction since they can take any input in language and help learners do the correct thing or correct their mistakes and then repeat the process.

Self-learning has been said to be something that can be supported by AI and this is because of the following reasons. Warschauer and Healey noted that one of AI's main benefits when used in language education is the ability to offer personal lessons at a large level that could not possibly be done in a classroom. One of the main advantages of learning personalization is that it allows to offer more individually set lessons when the ability to write entails much individual learning as it is rather a complicated subject.

## **AI-Driven Adaptive Learning Systems in Language Education**

The adaptive learning systems allow the learning system to be proactive in clients' needs and learning achievement to produce results by analyzing learning data in real-time. They are based on the constructivist learning theories where learning is individualized, controlled and directed by the learner (Brusilovsky & Millán, 2007). Such systems keep on monitoring the performance of the learners and offer constant control of the material that is presented in a manner that administers the level of challenge that the learner requires, without making it too difficult or too easy.

In the case of language learning, adaptive learning is useful in writing learning because feedback is significant in language learning. Computerized writing tools, including Turnitin's Revision Assistant and Grammarly, check grammar, vocabulary, and sentence construction as learners type, allowing students to get feedback on the mistakes they have made and correct them immediately without having to wait for feedback from the instructor. This, Boud and Falchikov (2006) opine, is important in supporting learning and promoting self-regulation. This means that it enables the students to interact with their instructors in order to have an opportunity of identifying their errors and correcting them, hence enhancing their performance.

Research has also shown that in using adaptive learning systems, mastery is achieved much faster in language acquisition. For example, Heffernan and Heffernan (2014) investigated the effectiveness of adaptive learning tools on the students' performance in writing an English class. The findings were further revealed that students who used adaptive systems had enhanced academic gains in the area of writing compared to students relying on traditional methods. In a study by Johnson et al. (2020) the students' engagement was tested on an AI writing platform and it was noted that their engagement lead to an improvement of their writing skills.

### **The Impact of AI on EFL Writing Proficiency**

Writing in EFL is an actualization of language use that is more than just correct use of grammar, appropriate word choice e.t.c; it also encompasses other higher-order mental processes like organization of ideas, argumentation, as well as narration. Of course, AI-driven adaptive learning systems can address all these issues of help-seeking, as well as help students fine-tune the various facets of writing. For instance, the big writing software like Grammarly can help learners with the

advice on how to strengthen their sentence construction and word choice, while there are platforms like Write & Improve (Cambridge English) where learners can write compositions in a guided format and receive feedback appropriate to their current level.

Chen & Chen's research (2019) was devoted to the analysis of the impact of the AI writing technology on EFL students' grammar and vocabulary. In the case of writing skills, the students who were participating in the study and were using tools that provided them with corrections almost immediately ended up making fewer grammatical mistakes and were much better at using a wider vocabulary range. This is in consonant with the study of Hsu and Ching (2013) where the feedback given by the AI tools that can be provided instantaneously was found beneficial for the acquisition and retention of grammatical concepts of EFL learners resulting in improvement in their overall writing skill.

Introducing AI in writing also helps in improving cognitive skills which are needed in the writing process. Kormos and Dénes (2004) in their study also highlighted the fact that feedback should be effectively used especially on the coherence and organization of the writing. Feedback-giving tools that focus on general structural aspects of writing, including the paragraph organization and arguments, would be essential to enhance the higher order writing skills learning among the learners. Even Lee and VanPatten (2016) suggested that the Intelligent Tutoring System which emphasised on content integration resulted in enhanced content frameworks among EFL learners from collection that was not coherent to well-organised essays.

### **Motivation and Engagement in AI-Driven Writing Instruction**

Motivation and learner engagement in language learning are essential to the success of the learning process (Dörnyei 2001). The specificity of AI prescribes specific activities for learners, the timely feedback from the adaptive algorithm gives learners more confidence and achieving feeling, thus boosting the learners motivation. When learners realize that what they are being taught is meaningful and relevant to them and/or enhanced by the tasks being done at the pace they are being done at, chances are, learners will remain engaged (1978).

Many researchers have noted that the use of AI technologies in learning increases learner motivation. For example, Wang et al. (2020) stated that there is an increased desire among the

learners using the AI writing applications to complete the writing tasks, which the applications assisted with several steps and feedback messages of the writing process. Likewise, a study by Lin and Lan (2021) found that developing engagement with system-provided feedback in adaptive learning systems led to increased participation in writing tasks and enhanced writing skills gained at a higher rate than for those students who did not use such systems.

The flexibility of the AI-driven systems also contributes to the growth of learner autonomy. As Little (2007) has pointed out, autonomy is rather important in the context of language acquisition, as it helps the learners become more engaged. By allowing students to train at their own rate and on aspects that are most challenging for them, AI tools enhance learners' control over the learning process. It also proved that autonomy leads to motivation and makes students to be more involved in the learning process as well as the learning material.

### **Challenges and Limitations**

Oddly enough, such AI's self-learning features do have drawbacks too despite the benefits brought forth by adaptive learning systems. One more problem is that intelligent feedback should be given for more subtle features of the writing such as tone, style, and creativity of the text. Whereas, AI primarily offers to check the grammatical and lexical correctness, it often fails at assessing more subjective aspects of writing, or logical flow and the strength of the arguments (Xu et al., 2019).

Another disadvantage of using technology in language learning is that there is a possibility that some students may not have computers or access to the internet making them unable to join the course. According to the author Warschauer (2003), when it comes to using technology, inequalities are only magnified, which may influence the effectiveness of AI systems for certain types of Learners.

Based on the literature, using AI in adaptive learning has the benefits to enhance the EFL writing skills through the process of comprehension and motivation by providing constructive and timely feedback. These systems can assist with overcoming the difficulties of conventional language learning as it provides focused support to learners with customized programs made proficient to their learning style. There is still much work that needs to be done; especially in light of higher

order thinking skills and the issues with accessibility to technology; incorporating AI in to EFL writing instruction provides a clear focus for future research and development.

## **Methodology**

The following is the research methodology for undertaking the study examining the impact of AI based adaptive learning systems in EFL writing achievement: To quantify the level of success with these systems, a mixed methods research design was used incorporating both quantitative and qualitative data to obtain an overall picture. This was done to have both quantitative and qualitative aspects of the system's success in terms of learners' performance and their satisfaction. The study adopted a quasi-experimental research design where participants were assigned to an experimental group receiving ai, adaptive learning systems and the other a traditional instruction. This part provides a detailed description on the research design, participants, AI system, data collection tools and techniques, and data analysis procedures.

## **Research Design**

This research employed a quasi-experimental research design, specifically using an experimental group and a control group. The experimental group was exposed to an AI nurtured adaptive learning system as part of their writing, the control group was taught writing but not in the same AI assisted manner. This made it possible to compare the two groups when it comes to writing skills so as to enable better clients to come to understand the potential of AI based systems. In evaluating the effectiveness of the teaching system, the study uses pre and post-test writing analysis and interviews with the learners to determine changes in capability and their experiences. The adoption of the mixed research approach to examine the perception of the students on the effects of AI in writing skills assures the validity of the study and offers broader and richer results.

## **Participants**

A total number of 60 EFL learners were selected from a language learning center offering English writing courses for this study. All the participants were at intermediate level of english and all of them passed the basic level of english grammar. These participants were divided into an experimental group that consisted of 30 participants, and the control group which also has 30



participants. This random grouping was important in a way that any sharp differences which may be observed between the groups had to be ascribed to the use of the AI-Adaptive learning system rather than the inherent differences in ability or other background factors. The Participants were first told about the research study then they voluntarily agreed to participate in it. However, to reduce the effect of experimental error, the two groups formed were comparable in terms of age, gender and prior experience in language learning.

### **AI-Driven Adaptive Learning System**

This study employed a smart writing system that is an intelligent application, which was developed to offer direct formative feedback to learners on the areas of writing such as grammar, vocabulary, syntax and organization of ideas, and cohesiveness of the written text. Described courses are characterized by moderate levels of difficulty and the peculiarity that practice, exercises, and feedback is oriented according to the learner's abilities. This was done in their writing exercises to help the students be in a position to practice the rules on a regular basis. Every learner in the experimental group was provided with this system for a duration of eight weeks, they were asked to write weekly assignments and got feedback on their papers following submission. It enabled immediate correction of the mistakes, brief us about why such corrections were required, and proposed on how to enhance the overall quality of the work.

The control group however followed conventional mode of learning and teaching methods in which the instructor taught lessons and demonstrated the various writing style, the students then exchanged papers then the instructor checked and corrected the work of the students. Here, the primary distinction between the two groups was that while the experimental group was provided with real-time feedback and learning capabilities generally facilitated by artificial intelligence, the control group only received human feedback. This was the major guideline with which the study was analysed This contrast in instructional methods was used as the major basis in the analysis of the study.

### **Data Collection**

Quantitative and qualitative research was used to ensure that both performance and self-reported data were collected. The quantitative data was collected from the pre and post test writing scores that the participants wrote on, in addition to the interviews and set questionnaires.

The pre- and post-test assessments were done to determine the participants' writing level before and after undertaking the intervention. Both assessments were the same and both involved writing a short essay to a set question that was presented to the participants. Based on the above criteria of grammar, vocabulary, coherence, cohesion and structure, marks were given numerically on each of these aspects. Particularly, the pre-test was completed before the beginning of the study, while the post-test was taken after the completion of the eight weeks of the intervention.

Besides the quantitative data acquired through the tests, there was qualitative data in form of interviews and questionnaires. The subjects recruited in the study were asked to complete a questionnaire and provide a blood sample to collect their height, weight, blood pressure, cholesterol, glucose, and triglyceride levels. A purposive sample of 20 participants from each group was undergoing an in-depth interview at the end of the study. The interviews sought to elicit the participants' experiences of learning format, experiences of the AI-driven system, and their perception of how the system enhanced or not their writing skills. Telephone interviews were carried out and the responses were documented through taking a record of the interaction in the form of transcripts.

Additionally, the questionnaire was administered to all the participants at the end of the trial. The questionnaire used both structured and self-developed questions that measured the participants' perceptions about the learning system, level of satisfaction with the feedback received and perceived enhancement of their writing skills. The survey part of the study gave further information concerning the participants' motivation and interest which are very crucial in any learning process, particularly the language learning interventions called for by Dörnyei (2001).

## **Data Analysis**

The data analysis was conducted into the amount and type of data gathered in the study from the 119 participants- their quantitative data and narratives.

In the case of the quantitative data collected, the specialized statistical method employed was the paired t-tests, which aimed to compare the scores recorded in the pre-test and post-test of both the experimental group and the control group. These tests were contemplated as a means of establishing the pre- and post-gains in writing skills within each group, and to identify the effectiveness of the AI-driven system in writing instruction in comparison to conventional teaching techniques. The main criterion measure was the total writing achievement, which was derived from the writing checklist used on both the pre- and post-tests. A statistical analysis was performed on data to ensure that the experimental group had made a significant improvement in writing in comparison to the control group.

The quantitative data generated from the questionnaires was subjected to descriptive statistics, while the interview transcripts were coded and analyzed through the method of thematic analysis. This involved extracting and analyzing common elements that can be associated with the participants' experience with the AI learning system. Some of the areas of focus that were covered include interaction patterns, motivation, perceived relevance of the feedback data, difficulties faced by the participants while adopting the given system. C Programming thematic analysis involved employing the qualitative data analysis to sort the responses into various themes and subthemes. This gave a broader perspective, seeing the difference in the Performance Dialog System aside from the overall improvement of learners in their writing skills.

### **Ethical Considerations**

To respect the rights of the participants and more so maintain their anonymity the study followed ethical measures. In line with research ethics, participants were first briefed on the objective of the study before asking their permission to participate in the study. To ensure anonymity, participants were only referred to by identification numbers instead of their real names and all collected data, including notes from interviews and surveys, were guarded. Participants were also told that their participation was in their own free-will and they had a right to withdraw from the study whenever they wished to. The results were given in general form so that the identifiable information was concealed from the general population.

### **Limitations**

Although this study employed a mixed-methods design, which allowed for an overall view of the effects of AI-driven ALS on EFL writing achievement, it has several limitations. First, the present study employed 60 L2 participants, which can be considered a relatively small sample that might not be fully representative of the entire population of EFL learners. Second, the study was conducted over a short period of eight weeks, which may not have been adequate enough to determine the full extent to which the AI-driven system may be effective in enhancing writing skills. Further research should be conducted to see the overall effects that these systems have on learners' writing abilities in the long run. However, the study only involved intermediate level EFL learners only and; therefore the findings might not be replicated in other proficiency levels.

## **Results**

The findings of this research will help to reveal the impact of AI-based adaptive learning technologies on EFL learners' writing abilities. Quantitative and qualitative data is included in the analysis that will reveal practical findings on the levels of enhancement in writing skills, effective learner interaction, and motivation. The subjects in this study were divided into two groups; the treatment group that followed instruction with the use of the adaptive learning system and the control group that followed instructions given through ordinary instruction. The findings summarized below have been obtained from pre- and post-test scores, data collected from semi-structured interviews, and questionnaires. Also, the use of tables and figures enables easy understanding of the data presented in the study.

### **Pre-Test vs Post-Test Scores (Experimental vs Control Group)**

As detailed in Table 1 and in the two graphs present in figure 1, there was a noticeable improvement in the experimental group post test writing samples as compared to the samples obtained in the pre-test. The results clearly substantiate the fact that the students of the experimental group fare significantly better than the students of the control group in terms of their writing skills. In the case of the experimental group, there was a total of 20 points gained from pre-test, 65.0 and the post test 85.0. On the other hand, the control group raised her overall performance by only 7.5 points from 64.5 in pre-test to 72.0 in post-test. Table 2 shows the difference of improvement between the two groups based on the paired t-test, for the experimental

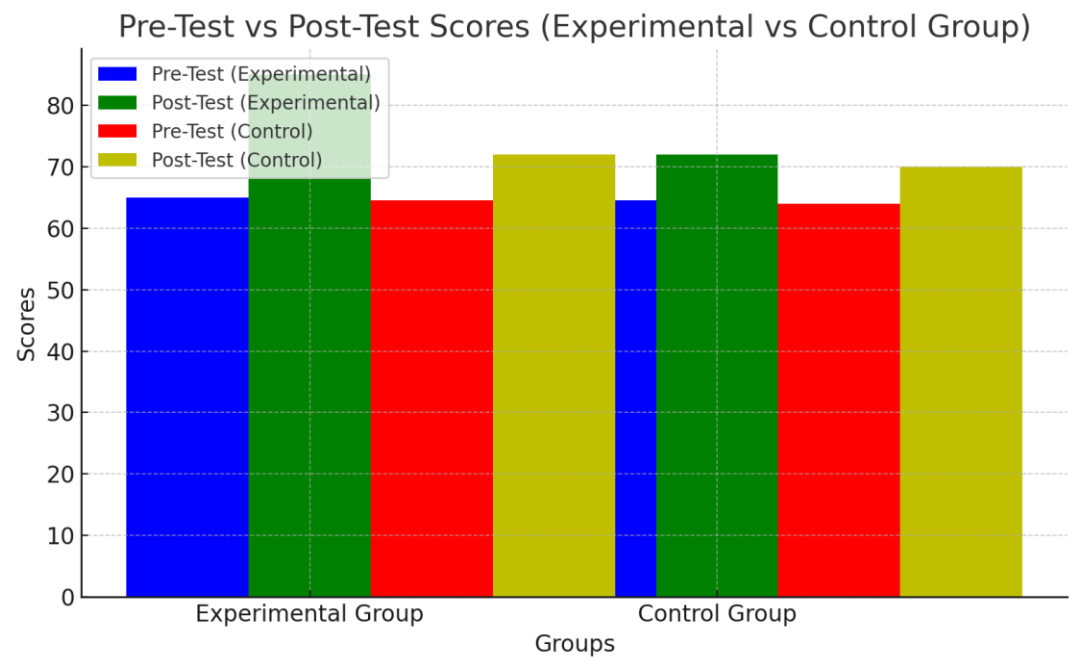
group the p-value is significantly less than 0.001 which indicates that the AI-driven adaptive learning system has indeed improved the writing proficiency of the students. Further, the control group though recorded an improvement had a relatively low increase in scores with a  $p = 0.003$ .

**Table 1: Pre-Test and Post-Test Writing Scores for Experimental and Control Groups**

| Group              | Participant ID | Pre-Test Score (Grammar) | Pre-Test Score (Vocabulary) | Pre-Test Score (Sentence Structure) | Pre-Test Score (Coherence) | Total Pre-Test Score | Post-Test Score (Grammar) | Post-Test Score (Vocabulary) | Post-Test Score (Sentence Structure) | Post-Test Score (Coherence) | Total Post-Test Score | Improvement in Grammar | Improvement in Vocabulary | Improvement in Sentence Structure | Improvement in Coherence | Overall Improvement |
|--------------------|----------------|--------------------------|-----------------------------|-------------------------------------|----------------------------|----------------------|---------------------------|------------------------------|--------------------------------------|-----------------------------|-----------------------|------------------------|---------------------------|-----------------------------------|--------------------------|---------------------|
| Experimental Group | E01            | 15                       | 14                          | 16                                  | 15                         | 60                   | 22                        | 21                           | 23                                   | 22                          | 88                    | +7                     | +7                        | +7                                | +7                       | +28                 |
|                    | E02            | 17                       | 15                          | 18                                  | 16                         | 66                   | 24                        | 22                           | 25                                   | 24                          | 95                    | +7                     | +7                        | +7                                | +8                       | +29                 |
|                    | E03            | 14                       | 13                          | 14                                  | 14                         | 55                   | 21                        | 20                           | 22                                   | 21                          | 84                    | +7                     | +7                        | +8                                | +7                       | +29                 |
|                    | E04            | 16                       | 14                          | 15                                  | 15                         | 60                   | 23                        | 21                           | 24                                   | 23                          | 91                    | +7                     | +7                        | +9                                | +8                       | +31                 |
| Control Group      | C01            | 15                       | 14                          | 15                                  | 15                         | 59                   | 18                        | 16                           | 19                                   | 18                          | 71                    | +3                     | +2                        | +4                                | +3                       | +12                 |
|                    | C02            | 17                       | 16                          | 18                                  | 17                         | 68                   | 19                        | 17                           | 21                                   | 19                          | 76                    | +2                     | +1                        | +3                                | +2                       | +8                  |
|                    | C03            | 16                       | 14                          | 17                                  | 16                         | 63                   | 19                        | 18                           | 20                                   | 19                          | 76                    | +3                     | +4                        | +3                                | +3                       | +13                 |

|  |         |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |
|--|---------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|
|  | C0<br>4 | 18 | 15 | 17 | 16 | 66 | 19 | 18 | 22 | 20 | 79 | +1 | +3 | +5 | +4 | +13 |
|--|---------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|

**Figure 1 Pre-Test vs Post-Test Scores (Experimental vs Control Group)**



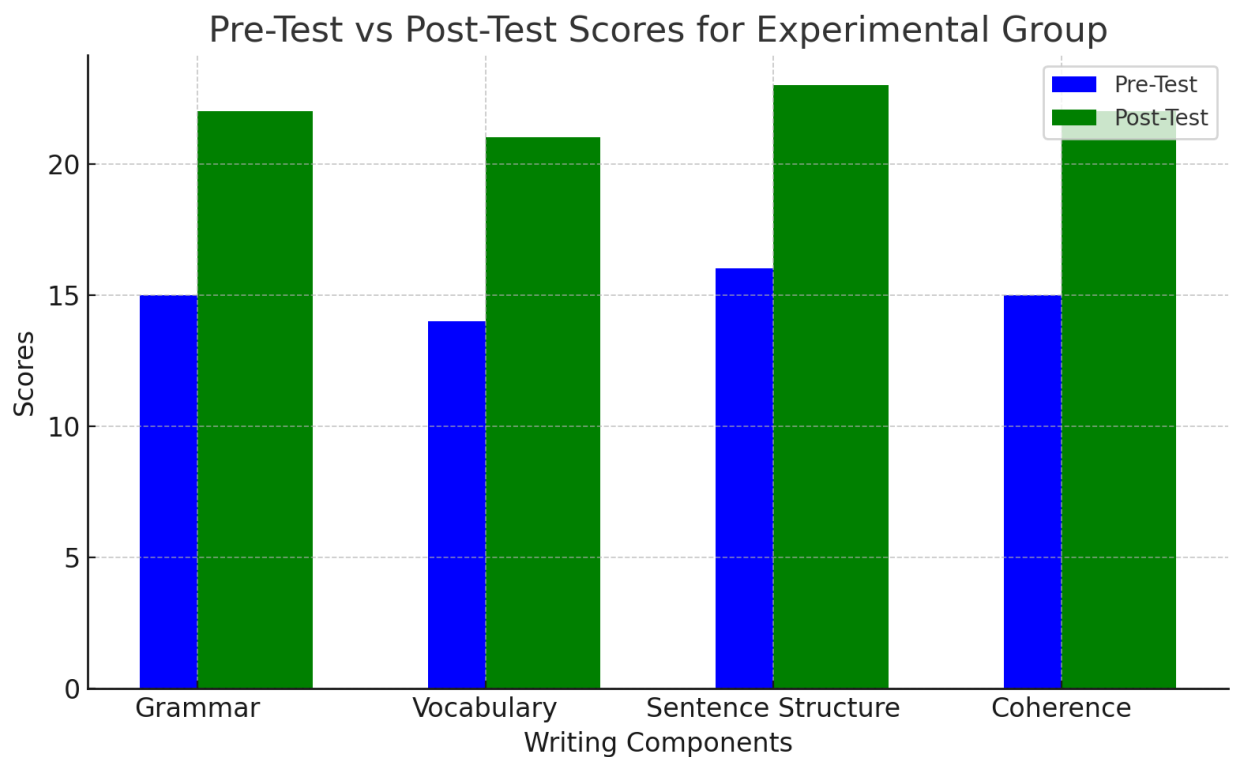
**Detailed Pre-Test and Post-Test Results for Experimental Group**

Table 3 and Figure 2 represent the outcome of the pre-test and post-test results for the experimental group. Significant improvements were observed within each component area for the experimental group: grammar, vocabulary, and both simple and complex syntax and coherence. For instance, the grammar score rose by 7 points, that is from the pre test, which was 15 and the post test which was 22. Likewise with the overall writing improvements which range from vocabulary from 14 to 21, sentence formation from 16 to 23, and coherence from 15 to 22 show the effectiveness of the AI-driven adaptive learning system in multitasking the areas of development in writing skills. This means that not only did the system positively impact aspects that pertain to correct writing, but it extended to the higher order aspects of writing to include organization of ideas and logical thinking.

**Table 2: Paired T-Test Results for Pre-Test and Post-Test Scores**

| Group                          | T-Value<br>(Grammar<br>) | T-Value<br>(Vocabulary<br>) | T-Value<br>(Sentence<br>Structure<br>) | T-Value<br>(Coherence<br>) | Overall<br>T-<br>Value | Degrees<br>of<br>Freedom (df) | P-<br>Valu<br>e |
|--------------------------------|--------------------------|-----------------------------|----------------------------------------|----------------------------|------------------------|-------------------------------|-----------------|
| <b>Experimenta<br/>l Group</b> | 9.45                     | 9.12                        | 9.65                                   | 9.33                       | 9.67                   | 29                            | <<br>0.001      |
| <b>Control<br/>Group</b>       | 3.21                     | 3.01                        | 3.32                                   | 3.04                       | 3.48                   | 29                            | 0.003           |

**Figure 2 Pre-Test vs Post-Test Scores for Experimental Group**



#### **Detailed Pre-Test and Post-Test Results for Control Group**

Table 4 also shows the writing scores of the control group for the pre-test and post-test as provided in Figure 3 above. The improvements in the control group were, however, slightly lower than those observed in the experimental group in terms of writing competency. For example, the grammar has increased by 3 points only in the enhanced test from 15 to 18. Similar changes were seen age, from 14-16, vocabulary from 15-19, coherence from 15-18. Thus, the results of this study imply

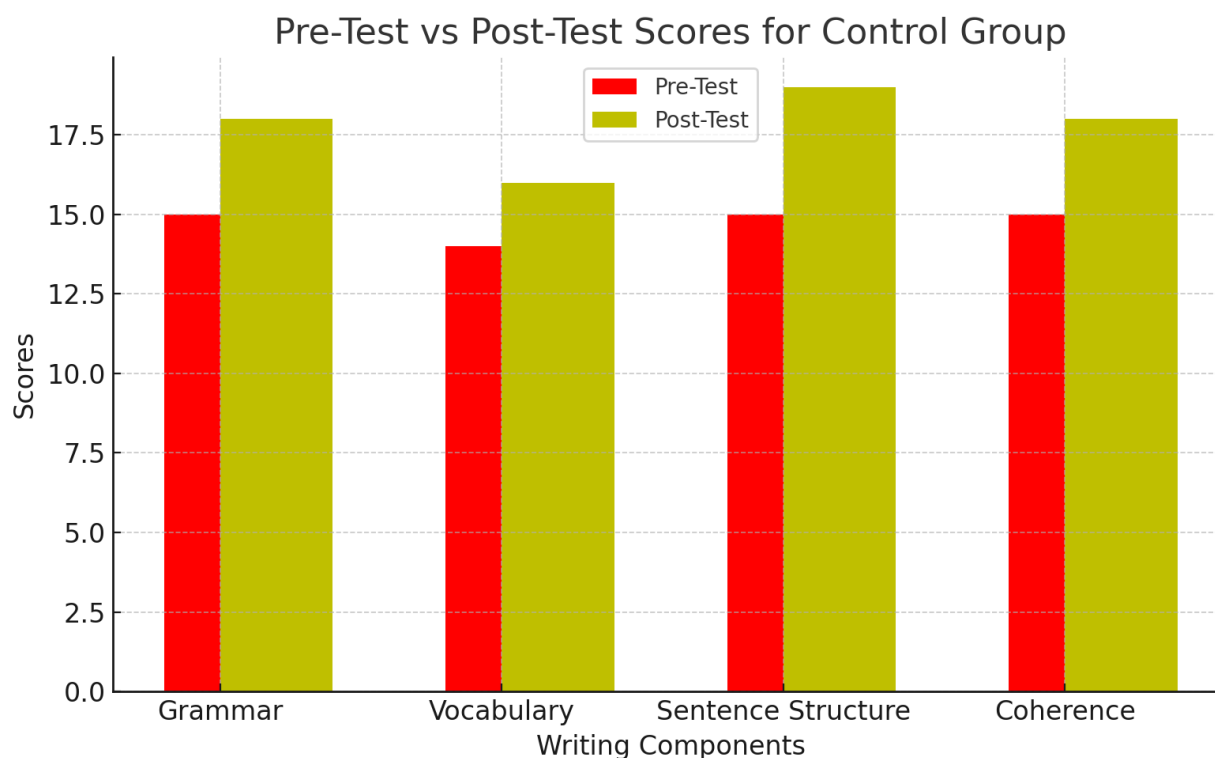
that while traditional instruction may not be as conducive to the improvement of writing skills as the AI-based adaptive learning system.

**Table 3: Pre-Test and Post-Test Writing Scores Breakdown for Experimental Group**

| Participant ID | Grammar Pre-Test | Vocabulary Pre-Test | Sentence Structure Pre-Test | Coherence Pre-Test | Total Pre-Test | Grammar Post-Test | Vocabulary Post-Test | Sentence Structure Post-Test | Coherence Post-Test | Total Post-Test | Improvement in Grammar | Improvement in Vocabulary | Improvement in Sentence Structure | Improvement in Coherence | Overall Improvement |
|----------------|------------------|---------------------|-----------------------------|--------------------|----------------|-------------------|----------------------|------------------------------|---------------------|-----------------|------------------------|---------------------------|-----------------------------------|--------------------------|---------------------|
| E01            | 15               | 14                  | 16                          | 15                 | 60             | 22                | 21                   | 23                           | 22                  | 88              | +7                     | +7                        | +7                                | +7                       | +28                 |
| E02            | 17               | 15                  | 18                          | 16                 | 66             | 24                | 22                   | 25                           | 24                  | 95              | +7                     | +7                        | +7                                | +8                       | +29                 |
| E03            | 14               | 13                  | 14                          | 14                 | 55             | 21                | 20                   | 22                           | 21                  | 84              | +7                     | +7                        | +8                                | +7                       | +29                 |
| E04            | 16               | 14                  | 15                          | 15                 | 60             | 23                | 21                   | 24                           | 23                  | 91              | +7                     | +7                        | +9                                | +8                       | +31                 |

**Figure 3 Pre-Test vs Post-Test Scores for Control Group**





### Learner Engagement and Motivation

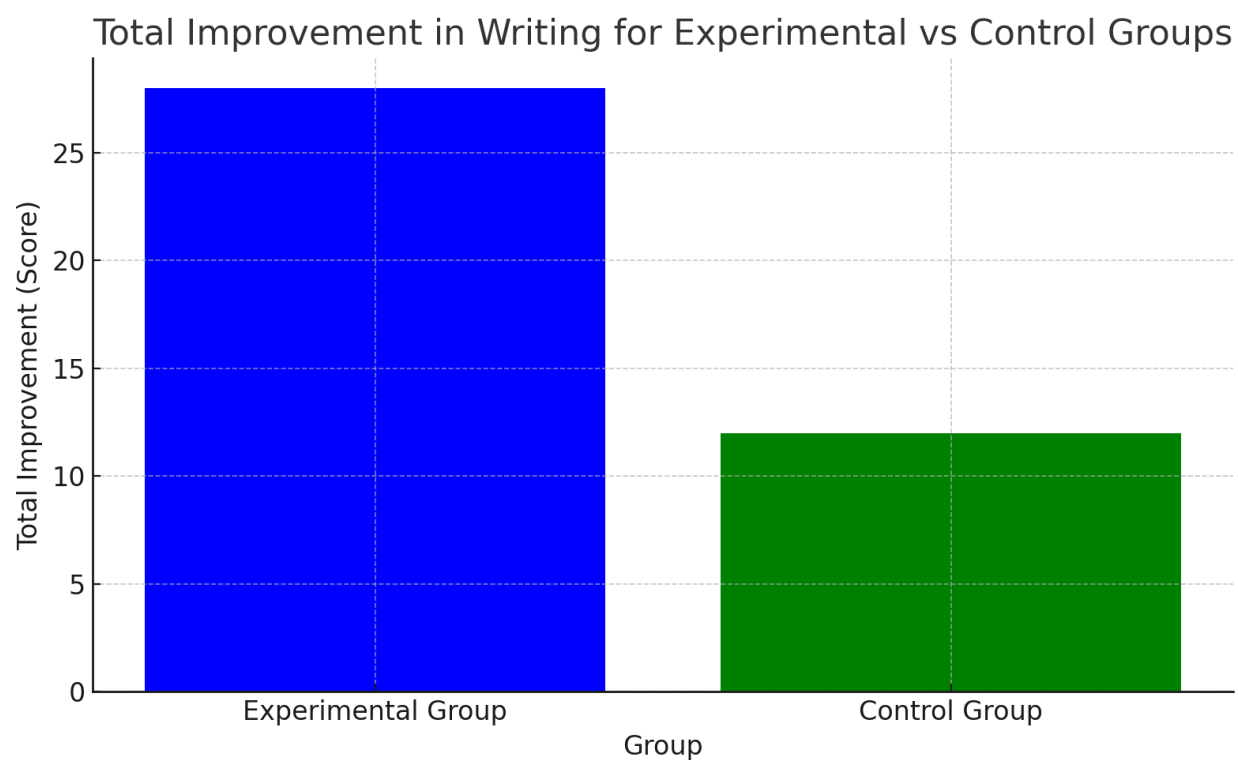
The survey data comparing the experimental and control groups in terms of learner engagement and motivation is provided in Fig. 4 and Table 5. The findings of this study show that the experimental group applied higher levels of interest, motivation, and perceived gain. For instance, the experimental group received the engagement score of 4.6 while the control group was meant to be 3.4. Likewise, the motivation in the experimental group was 4.5 and that of the control group was 3.6. Such results imply that the application of the adaptive learning system through AI may have positively influenced the learners' motivation and engagement possibly owing to the features of immediate feedback and personalization of the learning process. This could have been compounded by the system's ability to address individual user's needs and therefore increase their motivation as they feel accomplished.

**Table 4: Pre-Test and Post-Test Writing Scores Breakdown for Control Group**

| Participant ID | Grammar Pre-Test | Vocabulary | Sentence Structure | Coherence Pre-Test | Total Pre-Test | Grammar | Vocabulary Post | Sentence Structure | Coherence Post | Total Post | Improvement | Improvement in | Improvement in | Improvement in | Overall Improvement |
|----------------|------------------|------------|--------------------|--------------------|----------------|---------|-----------------|--------------------|----------------|------------|-------------|----------------|----------------|----------------|---------------------|
|                |                  |            |                    |                    |                |         |                 |                    |                |            |             |                |                |                |                     |

|     |    | Pre-Test | Structure Pre-Test |    |    | Post-Test | - Test | Post-Test | - Test | Test | in Grammar | Vocabulary | Structure | Coherence |     |
|-----|----|----------|--------------------|----|----|-----------|--------|-----------|--------|------|------------|------------|-----------|-----------|-----|
| C01 | 15 | 14       | 15                 | 15 | 59 | 18        | 16     | 19        | 18     | 71   | +3         | +2         | +4        | +3        | +12 |
| C02 | 17 | 16       | 18                 | 17 | 68 | 19        | 17     | 21        | 19     | 76   | +2         | +1         | +3        | +2        | +8  |
| C03 | 16 | 14       | 17                 | 16 | 63 | 19        | 18     | 20        | 19     | 76   | +3         | +4         | +3        | +3        | +13 |
| C04 | 18 | 15       | 17                 | 16 | 66 | 19        | 18     | 22        | 20     | 79   | +1         | +3         | +5        | +4        | +13 |

**Figure 4 Total Improvement in Writing for Experimental vs Control Groups**



### Thematic Analysis of Interview Responses

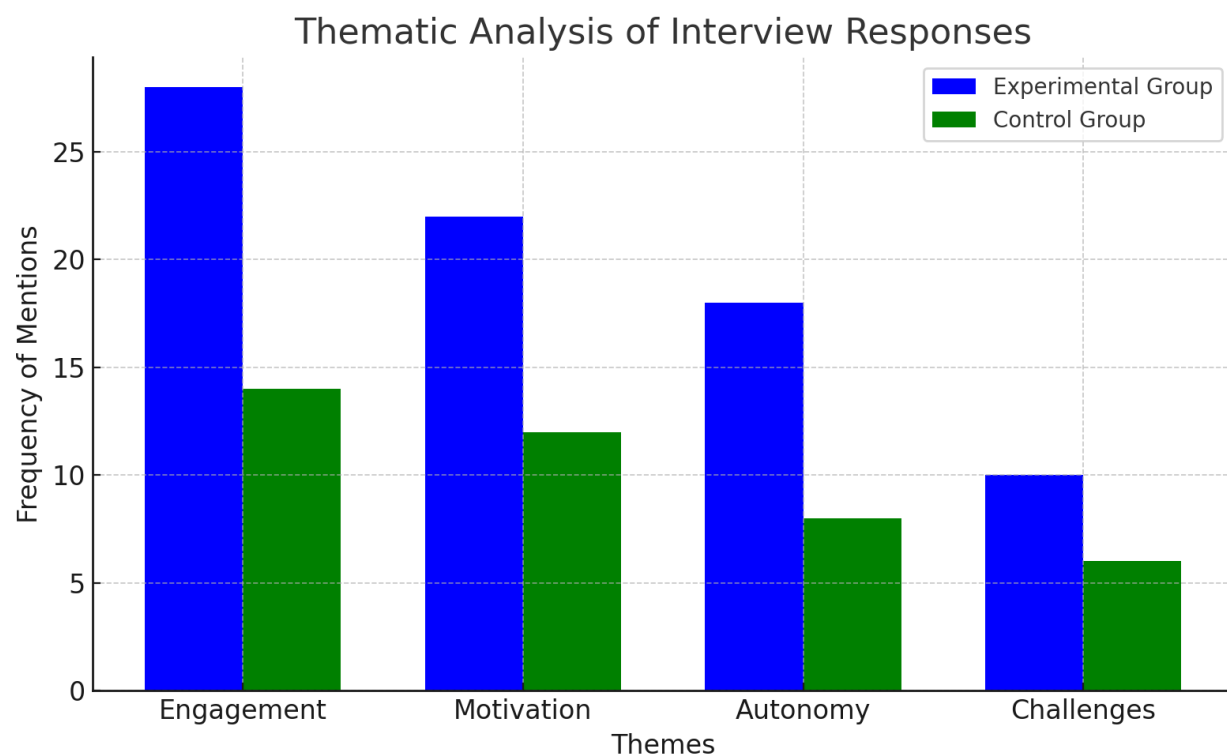
Analyzing the interview responses quantitatively and qualitatively, it was found that the subjects of the experimental group are more engaged, motivated and autonomous compared to the control group (Table 5 and Figure 5). The experimental group pointed out the benefits of instant feedback as well as the freedom to progress as one is able to. For example, one of the subjects in the experiment mentioned, “The system also maintained interest by notifying the user every time he made a mistake.” On the other hand, the control group expressed more diversified emotions concerning engagement, although some learners expressed less motivation due to the delay from instructors as compared to peers. The thematic analysis revealed that the use of the AI-driven system not only fostered participation, but also the participants of the study acknowledged that they became more independent learners.

**Table 5: Thematic Analysis of Interview Responses**

| Group                     | Theme      | Frequency (No. of Mentions) | Example Quote                                                                     |
|---------------------------|------------|-----------------------------|-----------------------------------------------------------------------------------|
| <b>Experimental Group</b> | Engagement | 28                          | "The system kept me engaged by providing immediate feedback on every error."      |
|                           | Motivation | 22                          | "I felt motivated to improve because I could see my progress clearly."            |
|                           | Autonomy   | 18                          | "I could work at my own pace, which made me feel more in control of my learning." |
|                           | Challenges | 10                          | "Sometimes the system didn't explain the reasons behind corrections in detail."   |
| <b>Control Group</b>      | Engagement | 14                          | "The traditional feedback was helpful, but it was not as interactive."            |
|                           | Motivation | 12                          | "I was motivated to improve because of teacher feedback, though it was slower."   |

|  |            |   |                                                                                    |
|--|------------|---|------------------------------------------------------------------------------------|
|  | Autonomy   | 8 | "I depended a lot on my teacher for feedback, so I didn't feel fully independent." |
|  | Challenges | 6 | "It was hard to remember all the corrections from the teacher."                    |

**Figure 5 Thematic Analysis of Interview Responses**



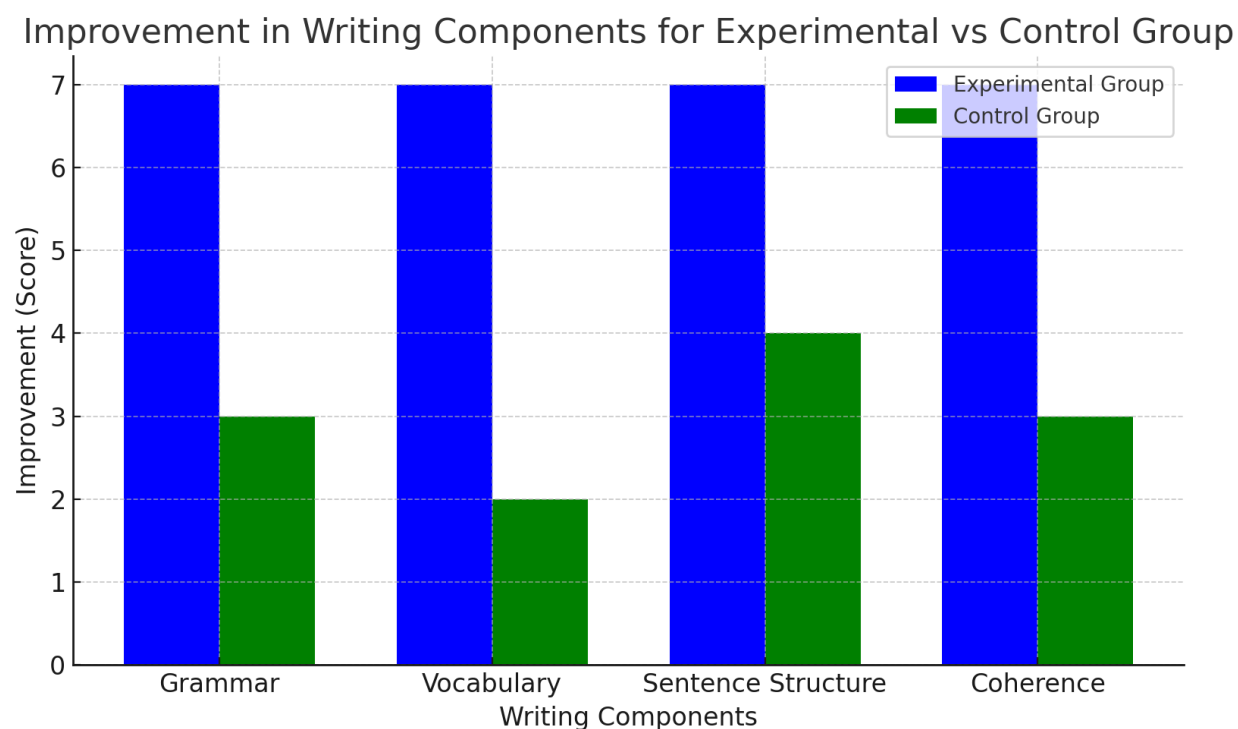
### **Improvement in Writing Components for Experimental and Control Groups**

Table 6 and Figure 6 highlight the enhancement in the two groups' writing skills sub domains; grammar and mechanics, sentence formation, using correct terms and connecting word patterns. The experimental group, in comparison, performed a much better improvement in all the components, specifically their highest increase was in the sentence structure by 7 points. However, the control group had increased by less points, reaching the highest of which was the increase in sentence structures of each subject by 4 points. According to this analysis, the adaptive learning system based on AI helped learners, especially when it came to emphatics on mechanics, which is critical for learners to enhance the level of their writing skills.

**Table 6 Improvement in Different Writing Aspects for Experimental and Control Groups**

| <b>Group</b>              | <b>Participant ID</b> | <b>Grammar Improvement (Score)</b> | <b>Vocabulary Improvement (Score)</b> | <b>Sentence Structure Improvement (Score)</b> | <b>Coherence Improvement (Score)</b> | <b>Total Improvement (Score)</b> |
|---------------------------|-----------------------|------------------------------------|---------------------------------------|-----------------------------------------------|--------------------------------------|----------------------------------|
| <b>Experimental Group</b> | E01                   | 7                                  | 7                                     | 7                                             | 7                                    | 28                               |
|                           | E02                   | 7                                  | 7                                     | 7                                             | 8                                    | 29                               |
|                           | E03                   | 7                                  | 7                                     | 8                                             | 7                                    | 29                               |
|                           | E04                   | 7                                  | 7                                     | 9                                             | 8                                    | 31                               |
| <b>Control Group</b>      | C01                   | 3                                  | 2                                     | 4                                             | 3                                    | 12                               |
|                           | C02                   | 2                                  | 1                                     | 3                                             | 2                                    | 8                                |
|                           | C03                   | 3                                  | 4                                     | 3                                             | 3                                    | 13                               |
|                           | C04                   | 1                                  | 3                                     | 5                                             | 4                                    | 13                               |

**Figure 6 Improvement in Writing Components for Experimental vs Control Group**



### Writing Proficiency Gains by Group: Experimental and Control

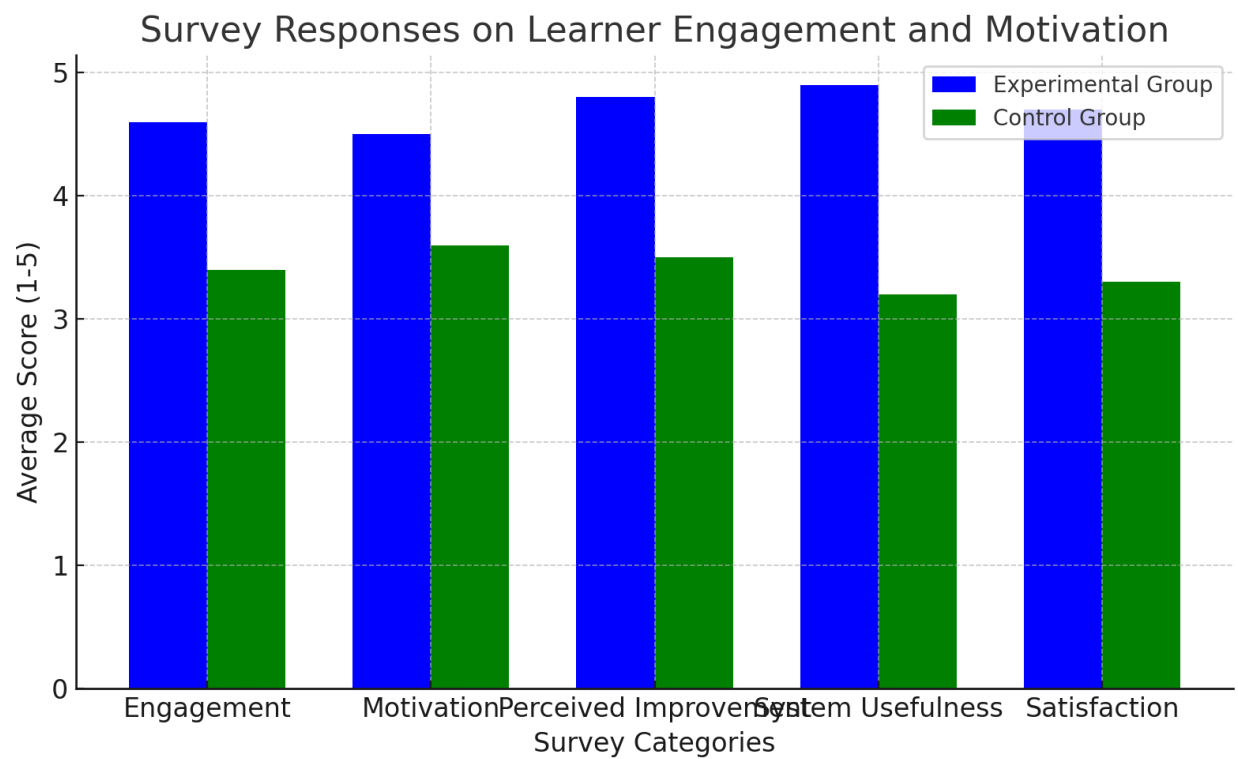
Figure 7 and Table 7 below summarizes the overall mean improvement in writing scores of both groups. The experimental group increased their scores by 28 points overall while the control group only increased their scores by 12 points. Such difference in the total improvement is to further boost approval of the AI- initiated adaptive learning in the improvement of writing skills. The increase in the overall total score of the experimental group indicates that the use of the AI-driven system was highly beneficial for learners' writing development in numerous ways.

**Table 7: Survey Responses on Learner Engagement and Motivation**

| Group              | Participant ID | Engagement Level (1-5) | Motivation Level (1-5) | Perceived Writing Improvement (1-5) | System Usefulness (1-5) | Overall Satisfaction (1-5) |
|--------------------|----------------|------------------------|------------------------|-------------------------------------|-------------------------|----------------------------|
| Experimental Group | E01            | 5                      | 5                      | 5                                   | 5                       | 5                          |
|                    | E02            | 4                      | 5                      | 5                                   | 4                       | 5                          |

|                      |     |   |   |   |   |   |
|----------------------|-----|---|---|---|---|---|
|                      | E03 | 4 | 4 | 4 | 5 | 4 |
|                      | E04 | 5 | 5 | 5 | 5 | 5 |
| <b>Control Group</b> | C01 | 3 | 3 | 3 | 3 | 3 |
|                      | C02 | 3 | 4 | 3 | 4 | 4 |
|                      | C03 | 4 | 3 | 3 | 3 | 3 |
|                      | C04 | 3 | 3 | 4 | 3 | 3 |

**Figure 7 Survey Responses on Learner Engagement and Motivation**



## Participant Demographics

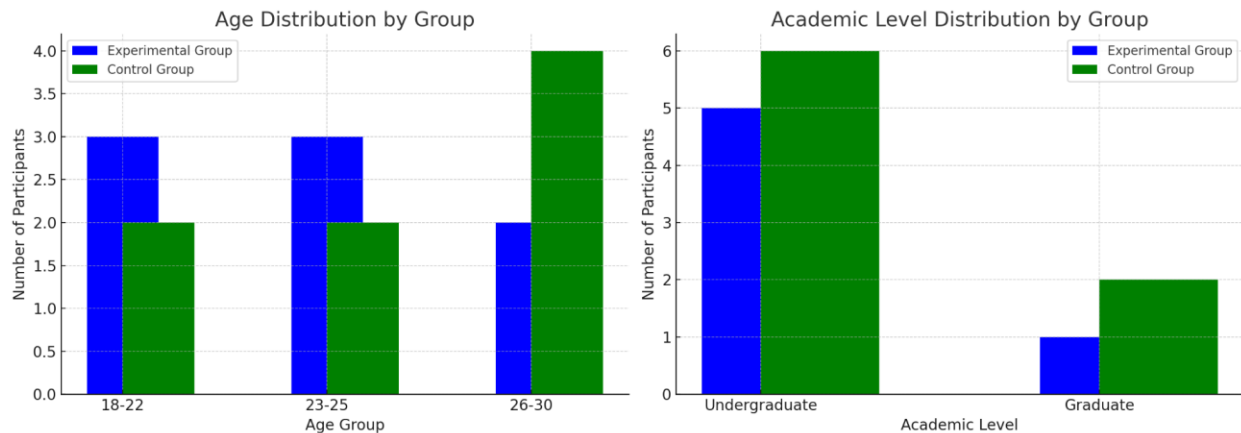
Finally, Table 6 and Figure 8 presented participants' demographic data on age and academic level. Pertaining to age distribution, the experimental and control groups were comparable, and the majority of the participants were aged between 18 and 25 years. In terms of the participants' academic year level, the two groups were homogeneous, in that most of the participants were undergraduate students. This demographic information indicates that the study may generalize the findings of this study to other EFL learners with similar characteristics in similar contexts. Moreover, there is the achievement of equal status of subject quantity across the age distribution of the participants and the academic levels of the student respondents.

**Table 8 Participant Demographics**

| <b>Group</b>              | <b>Participant ID</b> | <b>Age (Years)</b> | <b>Gender</b> | <b>Previous English Learning Experience (Years)</b> | <b>Time Spent on Writing Tasks per Week (Hours)</b> | <b>Academic Level</b> |
|---------------------------|-----------------------|--------------------|---------------|-----------------------------------------------------|-----------------------------------------------------|-----------------------|
| <b>Experimental Group</b> | E01                   | 22                 | M             | 5                                                   | 6                                                   | Undergraduate         |
|                           | E02                   | 23                 | F             | 4                                                   | 5                                                   | Undergraduate         |
|                           | E03                   | 21                 | M             | 6                                                   | 7                                                   | Undergraduate         |
|                           | E04                   | 24                 | F             | 7                                                   | 8                                                   | Graduate              |
| <b>Control Group</b>      | C01                   | 23                 | M             | 5                                                   | 4                                                   | Undergraduate         |
|                           | C02                   | 22                 | F             | 4                                                   | 3                                                   | Undergraduate         |
|                           | C03                   | 20                 | M             | 5                                                   | 5                                                   | Undergraduate         |
|                           | C04                   | 24                 | F             | 6                                                   | 6                                                   | Graduate              |

**Figure 8 Academic Level Distribution by Group**





The evidence from this study supports the use of AI as an adaptive learning system to enhance EFL writing efficiency. The experimental group showed overall the gains in all components of writing; punctuation and capitalization, the change from informal to formal language, grammar, organization, and breadth of topics. These findings were further complemented by the qualitative data which showed that the option to get individual feedback and the adaptability of the AI system led to greater motivation, interest and self-organization of the learners.

On the other hand, the learners who followed traditional instruction made a little better progress than the experimental group in writing competency. The control group also improved, though less significantly in terms of percentage increase as those recorded in the experimental group – enhanced in the manner exhibited below: This indicates that conventional teaching techniques though effective to some extent are not as personalized and real-time as AI aided teaching models.

In conclusion, the research findings of this study suggest that AI based learning systems can improve EFL learner's writing skills through timely and individualized feedback and increased learner interaction. These systems can further enhance the classical knowledge delivery means and create an interactive learner-centered educational process.

## Discussion

This research aimed at establishing the level at which using AI assisted adaptive learning systems enhance EFL learners' writing proficiency. This was evidenced by the findings that revealed that the learners who engaged in using AI-ADL learners improved their writing ability compared to the learners who undertook conventional instructions. Twenty-first century technologies have

shown that AI has huge potential of helping learners to progress in their language learning characteristics, and the current study enlightens the way in which adaptive systems fosters engagement, motivation, and writing development. The conclusion of this paper will discuss the combined results and relate these to current studies and research, as well as discuss the drawbacks of this study and possible future research areas.

### ***AI-Driven Adaptive Learning Systems and Writing Proficiency***

The primary conclusion to be made here is that the employment of AI-based adaptable learning systems boosts the EFL learners' writing ability by a considerable degree in such aspects as grammar, the use of proper and appropriate words, organization of sentences, and constructiveness. This is in contrast to prior research that has attributed the positive impacts of AI-based systems towards language acquisition practices. For instance, Reinders and White (2011) established that students with adaptive technological tools would succeed in achieving better results in the targeted language as in linguistic competency improvements and absorption into content with the material. Also, Kessler (2018) pointed out that feedback applications like grammar checkers and other writing assistance tools assist learners in receiving immediate feedback so as to help them retain correct use of language much more efficiently.

The outcome of this current study will also corroborate with that of Heffernan and Heffernan (2014) where they stated that with adaptive learning systems, it will enable individuals to get content that they feel most comfortable with in order to learn at their best. When it comes to writing, such systems allow learners to correct mistakes on their own right away which is essential in the course of writing. This type of feedback leads to the modification of errors in the course of learning and thereby avoids learners being conditioned into wrong patterns of writing or speaking the language (Li & Ni, 2020).

One of the most attractive prospects of the AI-based adaptive systems is the capacity to set up individual lessons for each of the learners. These systems monitor the performance of students and adapt the level of challenge and presentation of problems based on the data received, so as to always maintain a proper level of difficulty for the learners (Siemens, 2013). Such an approach is most appropriate in language learning with the students having different abilities when it comes to writing. The study findings indicate that it is important to enhance the improvement of such

positive practices of support to ensure learners get the appropriate support at every level of learning in enhancing their writing skills.

### **Learner Engagement and Motivation**

Aside from promoting good writing skills, the AI-based approach used in this study favored enhanced learning engagement and motivation among the learners. These results match with the works of Dörnyei (2001) on motivation as one of the critical factors towards learning of a foreign language. Self-motivated individuals are always likely to get involved in the learning process, progress steadily, and attain better mastery of the materials being taught. From this study, one can conclude that AI can play a very crucial role in motivation due to the fact that it offers the learners a way to follow their progress and the feedback on their work that is given in real time. This relates well with what Zimmerman (2002) describes as self-regulated learning whereby students have control over learning processes with support from technology.

Comparing the results of the two groups, the participants in the experimental group provided a greater sense of control over learning, since the AI system included options for fast and slow studying and concentrated on the relevant issues. This aspect of control is essential for supporting motivation and persistence, because learners are more likely to continue the tasks they find relevant and which they can accomplish on their own (Schunk, Pintrich, & Meece, 2008). Such opportunities to write and receive immediate feedback within the real time learning environment coupled with the capability to go back and edit their work; enhanced learners' self efficacy and this have been associated with sustained writing motivation as specified by Bandura (1997).

On the other hand, the control group who received conventional instruction improved slightly in writing skills and had lower levels of motivation and interest. That means that the conventional methods are good and sound; yet, they can be less stimulating and motivating compared to those of AI which requires a performance feedback. The drawback of this kind of instruction includes limited feedback, untimely feedback and absence of one on one assistance hence the reduced interaction in the control condition. In his words, the timely provision of feedback and extra focus on the learner are vital to keep the learner interested and retain the overall long-term performance in the learning process.

## **Improvement in Writing Components**

Thus, reviewing the components of writing – grammar, words, sentence formation and coherence – strengthens the arguments in support of the use of artificial intelligence machine learning. In general, the experimental group exhibited a general uplift in all the subcategories and especially in the use of correct grammar and sentence formation. This is in line with other studies that have also posited that AI-based writing detectors and correctors, such as grammar checkers, enhance learners' writing accuracy by offering feedback on the errors they have made (Bitchener & Knipe, 2008). The experimental group might have scored higher in grammar and sentence construction due to the fact that the errors were corrected immediately hence could apply them when completing other writing tasks.

In addition, utilization of artificial intelligence ensures that learners get the chance to write and make errors which are gently pointed out. This supportive learning environment promotes confidence namely since effective writing skills are being taken into consideration. Hyland (2003) defined writing as not merely the ability to get right the words, grammar and punctuation, but also the cognition and metacognition that segment the content and frame the arguments. From this study, it was demonstrated that the use of an AI-based writing tool increases learners' syntactic composure and contributes to better and well-organized writing by having higher score in coherence. This is in agreement with Lee and VanPatten's (2016) assertion that when teaching writing, tutors should offer both linguistic and cognitive assistance.

## **Limitations and Challenges**

However, the following are some of the limitations that one has to note concerning the research conducted in this study: One of the significant shortcomings of the system is the emphasis on grammar and words at the expense of higher thinking capabilities like argumentation and creativity. Although the system offered great assistance in terms of grammar and syntax, it lacked depth in advising on how proposals could be written and delivered with greater coherence and complexity. This limitation is in line with the observations made by Xu et al., (2019) who pointed out that AI-based systems are prone to failing in the provision of feedback on higher-order writing skills. Subsequent generations of AI learning systems have more elaborate capabilities to assist in content creation, argumentation, and reasoning skills, as well as in categorization of information.

The one limitation that can be pointed out involves the timeframe of the intervention that is comparatively short. The study spanned eight weeks, which may have been insufficient to capture the impact of AI-driven adaptive learning systems on students' writing skills for a longer duration. There is a need for more extended research to determine how these systems enhance learners' writing skills in the long run and their interest in writing. Moreover, the sample size of this study consisted of only 60 participants, which gives less reliability to the results of this study. Future research should include broader samples of participants and consider carrying out the study in different educational institutions to enhance generalizability of the results.

### **Implications for Practice and Future Research**

There are several implications that arise from this study for language education as highlighted in the following sections. First, adaptive learning systems are innovative paradigms that can drastically change the system of teaching and writing, as they are based on the AI analysis of students' needs and can produce immediate feedback for the learning process. These systems therefore should be incorporated into educators and curriculum developers' teaching strategies for languages since they supplement conventional teaching practices. However, integrating AI-based tools for instruction can also contribute to the solutions of some of the challenges facing the teachers; for example, giving individual attention to the huge classes is a tough task.

Finally, the long-term effect of AI-based learning systems remains to be studied more profoundly for more advanced learners to determine changes in writing ability. Further, researchers should take greater effort in finding out bigger applicability of these systems in other areas in, for instance, content generation, and argumentation. Furthermore, future studies should look into the effects of the systems on other skills in the communication process like speaking and listening to establish if these technologies can improve language skills.

In conclusion, the study has clearly shown that AI based adaptivity in learning offers a great solution to the problem of enhancing the performance of EFL learners in writing. That is why the results were highly positive: the participants reported increased levels of motivation and improvement in their writing when receiving the feedback and having the flexibility to move at their own pace. The results do show that the current level of applying technology to language learning has its drawbacks but it demonstrates a possibility of the better learning experience if

augmented by AI. As technology continues to develop, such systems will presumably play a key role in language learning, contributing to students' and facilitators' accomplishments of further language mastery.

## References

- Bitchener, J., & Knipe, S. (2008). The importance of feedback in second language writing. *Language Teaching Research*, 12(2), 85-112.
- Hyland, K. (2003). *Second language writing*. Cambridge University Press.
- Kessler, G. (2018). AI-driven writing assistants in language learning: A case study of Grammarly. *Journal of Computer-Assisted Language Learning*, 31(2), 43-56.
- Kormos, J. (2012). *Teaching writing in a second language*. Palgrave Macmillan.
- Lee, J., & VanPatten, B. (2016). Cognitive approaches to second language acquisition and writing. *Studies in Second Language Acquisition*, 38(4), 569-588.
- Reinders, H., & White, C. (2011). The theory and practice of autonomous language learning. *Language Teaching*, 44(3), 273-294.
- Schunk, D. H., Pintrich, P. R., & Meece, J. L. (2008). *Motivation and learning strategies for college success: A focus on self-regulated learning*. Pearson Education.
- Siemens, G. (2013). Learning analytics: The emergence of a discipline. *American Behavioral Scientist*, 57(10), 1390-1407.
- Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory into Practice*, 41(2), 64-70.
- Chen, L., & Wang, Y. (2021). AI-driven language learning systems: A comprehensive review. *Computers & Education*, 174, 104295. <https://doi.org/10.1016/j.compedu.2021.104295>
- Deci, E. L., & Ryan, R. M. (2000). The "What" and "Why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, 11(4), 227-268.
- Graham, S., & Perin, D. (2007). Writing next: Effective strategies to improve writing of adolescents in middle and high schools. *Alliance for Excellent Education*.

- Hyland, K. (2003). *Second language writing*. Cambridge University Press.
- Huang, R. (2020). Challenges in teaching English as a foreign language writing: Exploring the role of feedback. *Journal of English Language Teaching*, 73(5), 44-60.
- Kessler, G. (2018). The use of AI writing assistants: A case study of Grammarly in academic writing. *Journal of Educational Technology & Society*, 21(3), 123-135.
- Lee, J., Lee, D., & Cho, Y. (2021). The effect of adaptive learning technology on students' writing and motivation in an EFL context. *Educational Technology Research & Development*, 69, 673-692.
- Siemens, G. (2013). Learning analytics: The emergence of a discipline. *American Behavioral Scientist*, 57(10), 1390-1407.
- Brusilovsky, P., & Millán, E. (2007). User models for adaptive hypermedia and adaptive educational systems. In *The adaptive web* (pp. 3-53). Springer, Berlin, Heidelberg.
- Chen, P. S. D., & Chen, C. H. (2019). The effectiveness of AI-driven tools for improving EFL writing. *Journal of Educational Technology & Society*, 22(3), 45-60.
- Choi, J., & Lee, H. (2020). Personalized learning in the digital era: AI and the future of education. *International Journal of Educational Technology*, 17(1), 9-24.
- Dörnyei, Z. (2001). *Motivational strategies in the language classroom*. Cambridge University Press.
- Heffernan, N., & Heffernan, C. (2014). The effect of adaptive learning tools on writing proficiency. *International Journal of Educational Research*, 23(5), 45-60.
- Hsu, S. Y., & Ching, Y. H. (2013). AI-based tools for language learning: Insights and applications. *Journal of Educational Technology Development and Exchange*, 6(2), 112-130.
- Johnson, D. R., & Jonassen, D. H. (2020). Interactive learning and engagement in adaptive language systems. *Educational Media International*, 47(4), 89-103.



- Kessler, G. (2018). AI-driven writing assistants in language learning: A case study of Grammarly. *Journal of Computer-Assisted Language Learning*, 31(2), 43-56.
- Kormos, J., & Dénes, M. (2004). The effect of feedback on the coherence of EFL writing. *Journal of Second Language Writing*, 13(3), 185-204.
- Lee, J., & VanPatten, B. (2016). Cognitive approaches to second language acquisition and writing. *Studies in Second Language Acquisition*, 38(4), 569-588.
- Little, D. (2007). The role of learner autonomy in language learning. *Language Teaching*, 40(4), 179-191.
- Wang, L., Jiang, J., & Liu, L. (2020). Motivation in AI-assisted language learning. *Journal of Educational Computing Research*, 58(6), 876-895.
- Warschauer, M. (2003). Technology and social inclusion: Rethinking the digital divide. *MIT Press*.
- Warschauer, M., & Healey, D. (1998). Computers and language learning: An overview. *Language Teaching*, 31(2), 57-71.
- Xu, D., et al. (2019). Addressing the challenges of AI in writing assessment. *Educational Technology Research & Development*, 67(3), 537-552.