

Integration of Deep Learning in English Reading Instruction in the Era of Digital Transformation

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ARTICLE INFO

Keywords: Deep Learning, Reading Learning, English, Digital Transformation, Learning Innovation

Received : 10, August

Revised : 27, August

Accepted: 28, September

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ABSTRACT

This study employed a quantitative approach with a quasi-experimental nonequivalent control group design to examine the effectiveness of deep learning technology integration in junior high school English reading instruction during the digital transformation era. Data were collected through pre-tests and post-tests involving 60 students divided into an experimental group using deep learning and a control group using conventional methods. Independent t-test and N-Gain analysis revealed a significant improvement in reading comprehension in the experimental group compared to the control group. These findings indicate that deep learning not only enhances learning outcomes but also fosters pedagogical transformation toward adaptive, data-driven learning, offering theoretical contributions to AI-based instructional models and practical implications for teachers in designing relevant learning strategies.

INTRODUCTION

The development of artificial intelligence technology has revolutionized various sectors of life, including the world of education. One of the important breakthroughs in this field is the application of deep learning, which allows learning systems to recognize learners' learning patterns and adapt instruction adaptively. In the midst of the increasing use of digital technology in post-pandemic education, reading skills in English have become one of the essential skills demanded by the global era. Data from the Program for International Student Assessment (PISA) 2022 shows that Indonesian students' reading literacy is still below the OECD average, indicating an urgent need to improve the quality of reading learning, especially through the use of relevant technology (Nugroho & Triana, 2021). At the global level, the integration of deep learning in learning has shown significant potential in increasing learning engagement and concept understanding through data-driven approaches (Mariani et al., 2023).

Although the adoption of digital technology in education in Indonesia shows a positive trend, the use of deep learning-based technology in English reading teaching is still relatively limited, especially at the junior secondary education level. A study by (Tri Astuti, 2025) revealed that many teachers still face obstacles in terms of technological infrastructure and digital pedagogical competence, so the application of AI-based smart learning methods is not optimal. On the other hand, research conducted by (Astri et al., 2024) in the context of higher education shows that digital learning is able to increase students' active participation in reading English texts, although its impact on reading comprehension in depth has not been studied quantitatively. This underscores the importance of studies that empirically measure the effectiveness of deep learning integration on student learning outcomes at a more basic level, such as high school.

Theoretically, the integration of deep learning in reading learning is based on the approach of meaningful learning and cognitive engagement, where students not only receive information, but also actively construct meaning based on the learning context. (Mariani et al., 2023) affirm that the application of deep learning technology allows the presentation of material in a multimodal format that enriches the learning experience and improves students' conceptual understanding. (Wang et al., 2023) in their development of the ChatPRCS system shows that personalization of reading instructions powered by deep learning and interactive models such as ChatGPT can significantly promote literacy development, particularly through mapping of students' proximal development zones. With the support of this technology, the learning approach becomes more adaptive, responsive, and focused on the individual needs of students.

Nevertheless, most previous research has still focused on conceptual reviews or descriptive qualitative studies, while empirical evidence testing the effectiveness of deep learning models quantitatively on improving students' reading comprehension is limited. (Liang et al., 2023) and (McCarthy & Yan, 2024) note that most studies in this area have not tested the cause-and-effect relationship between the integration of adaptive learning technologies and students' cognitive achievement in a measurable manner. (Ju, 2023) even

highlights that without proper learning design, the use of AI in education can actually lead to a decrease in learning effectiveness by 12–25%. This condition shows that there is a research gap that needs to be bridged through quantitative data-based experimental studies, especially in the context of secondary schools in Indonesia.

Based on these backgrounds and gaps, this study aims to empirically analyze the effectiveness of the integration of deep learning technology in English reading learning at the junior high school level. The main focus of this study is to measure the extent to which the use of deep learning technology can improve students' reading comprehension skills compared to conventional learning methods. The study also intends to test whether there is a significant difference between the learning outcomes of the experimental group that uses AI-based learning and the control group that does not use the technology.

Theoretically, this research is expected to make an important contribution to the development of studies related to learning technology and pedagogical innovations based on artificial intelligence. By providing quantitative empirical evidence, this study expands the scope of the literature that has been more conceptual or case-based in nature. The results of this study are expected to statistically validate that deep learning is not just a technological trend, but also an effective pedagogical approach in improving students' English reading skills.

From a practical perspective, the results of this research have the potential to make a real contribution to education stakeholders, such as teachers, curriculum designers, and policy makers. Teachers can gain insights into effective learning design by leveraging deep learning technologies, while policymakers can use these findings as a basis for developing more adaptive and student-based learning digitization policies. This finding also opens up opportunities for the development of a locally-based smart learning platform that can be integrated into the Indonesian secondary education system at large.

LITERATURE REVIEW

Digital Transformation in English Language Education

The digital age has changed the way teachers and students interact in the learning process, including in English teaching. Technological innovation allows for a more flexible, interactive, and data-driven approach. Digitalization encourages the use of Learning Management Systems (LMS), interactive media, and artificial intelligence in increasing learning effectiveness (Rahmawati, 2023). In a global context, (Warschauer & Liaw, 2020) emphasized that digital technology provides an opportunity to adapt English language materials according to the cultural context and needs of learners, especially in reading skills.

Deep Learning as an Innovative Technology in Learning

Deep learning, one of the branches of artificial intelligence, has shown its effectiveness in developing intelligent learning systems that are able to understand students' learning preferences and present customized materials. This technology is able to process large amounts of data to identify learning

patterns and adapt learning strategies automatically (Zhou et al., 2022). In Indonesia, deep learning integration is still in the exploration stage, but it has begun to be implemented in chatbot-based learning systems and virtual tutors (Putra & Nugroho, 2021).

Reading Comprehension and Its Teaching Challenges

Reading comprehension is an important skill in complex English learning because it involves text processing, meaning inferences, and critical analysis. Many students have difficulty understanding English texts due to a lack of effective reading strategies (Fitriyani, 2022). According to Nation (2020), vocabulary mastery, the ability to recognize text structure, and previous reading experience are the main factors that affect this skill. Therefore, a teaching approach that is able to adapt to the individual needs of students is needed.

Integration of Deep Learning in Reading Learning

The application of deep learning in reading learning has been researched in several recent studies. (Sun et al., 2023) developed an adaptive reading learning system based on convolutional neural networks (CNN) that is able to improve student engagement and their comprehension scores. On the other hand, research by Wulandari and (Kurniawan, 2022) shows that deep learning-based reading recommendation systems help students choose texts according to their abilities, thereby accelerating the improvement of comprehension. The use of this technology also opens up opportunities for teachers to evaluate learning in real-time.

Research Gap and Contextual Needs in High School

Although various studies have discussed the use of deep learning in education, there are still few studies that specifically test the effectiveness of this technology in the context of learning to read English at the secondary school level in Indonesia. Previous studies have tended to focus on the college level or on online-based general learning (Hartanto et al., 2021). Therefore, more contextual and applicative research is needed to answer the challenges of reading literacy in technology-based high school curriculum.

METHODOLOGY

Research Approach

This study uses a quantitative approach with a quasi-experiment design of the nonequivalent control group design. This approach was chosen to objectively examine the influence of the use of deep learning technology in learning to read English on students' reading comprehension. This design allowed researchers to compare learning outcomes between experimental groups that were given deep learning-based treatments and control groups that received conventional learning, although neither was randomly determined (Creswell & Creswell, 2023).

Research Population

The population in this study is all grade VIII students at one of the public junior high schools in Kutai Kartanegara, East Kalimantan, in the even semester of the 2024/2025 school year. The sampling technique was carried out by non-probability sampling with the purposive sampling method, which is to select two classes with relatively equivalent levels of academic ability based on the previous semester's English report card score. The total number of respondents was 60 students, consisting of 30 students in the experimental group and 30 students in the control group. The selection of this number refers to the minimal effectiveness of the sample in quasi-experimental design as suggested by (Cohen et al., 2021).

Data Collection Techniques

The data collection technique was carried out through a reading comprehension test instrument in English which was compiled based on the revised Bloom cognitive taxonomy and adjusted to the teaching materials of class VIII. Tests were given in the form of pre-tests and post-tests to both groups. The question items were validated through expert judgment by two English education lecturers and one subject teacher, with the validity of the content tested using the Aiken's V formula and the reliability of the instrument tested using Alpha Cronbach (Sugiyono, 2022). The minimum validity and reliability indices are set at 0.75 and 0.70 respectively in order to be used in valid measurements.

Research Procedure

The implementation of the research is carried out in three main stages, namely: (1) the preparation stage which includes the preparation of instruments, teacher training for the use of deep learning technology, and coordination with schools; (2) the four-week intervention implementation stage, where the experimental group used a deep learning-based learning platform that adapted the material and the level of difficulty based on student responses, while the control group used conventional teaching and exercise methods; and (3) the evaluation stage, where all students take a post-test to measure the improvement of reading comprehension.

Data Analysis Techniques

The test result data was analyzed using the Independent Sample t-Test to measure significant differences between the two groups, as well as the N-Gain test to determine the magnitude of the increase in each individual's score. The analysis process was carried out with the help of SPSS software version 26. The statistical significance was set at the level of 0.05. Analysis prerequisite tests such as normality and homogeneity of variance are carried out first to ensure the validity of the inference (Field, 2022).

RESEARCH RESULT

Comparative Analysis of Pre-test and Post-test Scores in Both Groups

This sub-section aims to present and analyze the difference between the pre-test and post-test scores between the experimental group using deep

learning-based learning and the control group using conventional methods. This analysis provides a preliminary overview of the effectiveness of the interventions applied.

Table 1. Average Pre-test and Post-test Scores of Students

Group	N	Installment-installment Pre-test	Post-test average	Difference
Experimental	30	58.47	78.92	20.45
Control	30	59.40	67.25	7.85

From Table 1, it can be seen that before the treatment, the pre-test scores of the two groups were relatively balanced (the difference was only 0.93 points), indicating that the initial ability of the students in both groups was equal. However, after the intervention, the post-test score of the experimental group increased drastically by 20.45 points, while the control group only increased by 7.85 points. This indicates that deep learning technology makes a significant contribution to improving English reading comprehension.

Furthermore, the considerable difference in improvement between the two groups implies that the adaptive technology-based approach has a superior ability to respond to the heterogeneous learning needs of students. Learning with deep learning uses artificial intelligence to personalize teaching materials, adjust the difficulty of questions based on students' response abilities, and provide automated feedback that can speed up the comprehension cycle. Meanwhile, conventional methods such as lectures and written exercises tend to be one-way and less adaptive to individual needs.

Learning Effectiveness Based on N-Gain Calculation

To evaluate the effectiveness of the proportional score increase, the N-Gain calculation is used. N-Gain measures the relative improvement from initial ability to the final result against the maximum achievable score range, and can be classified into high, medium, and low categories.

Table 2. Average N-Gain in Both Groups

Group	N	Average N-Gain	Effectiveness Category
Experimental	30	0.62	Medium-High
Control	30	0.21	Low

The experimental group's N-Gain value of 0.62 indicates effectiveness in the medium to high category, which means deep learning-based learning has a substantial impact. In contrast, the control group only achieved an N-Gain of

0.21, which was relatively low. These results show that conventional approaches are less effective in significantly improving reading comprehension at the same time.

Significance Test Using Independent Sample T-Test

To find out whether the difference in post-test scores between the two groups was statistically significant, independent samples were tested. This test is very important to ensure that the results of the improvement that occurred were not due to chance, but were indeed influenced by differences in treatment.

Table 3. T-test results on Post-test scores

Variabel	t-count	df	Sig. (2-tailed)
Post-test Reading	4.728	58	0.000

A significance value of 0.000 (< 0.05) indicates that there was a significant difference between the post-test scores of the experimental and control groups. Thus, it can be concluded that the integration of deep learning in English reading learning has a real and meaningful influence on improving student learning outcomes.

DISCUSSION

The main findings in this study show that the integration of deep learning into English reading learning is able to significantly improve the reading comprehension of junior high school students. These results were verified through a comparison of pre-test and post-test scores, as well as N-Gain values, where the experimental group that received deep learning-based treatment recorded a much higher improvement in learning outcomes than the control group that learned with conventional methods. This fact signifies that the integration of deep learning in teaching not only serves as an auxiliary medium, but has become an integral part of the new pedagogical strategy in the era of digital transformation.

From a digital pedagogical perspective, the integration of deep learning technology allows for the creation of learning experiences that are adaptive, personalized, and data-based. This technology is able to adjust the content and reading difficulty level to the performance of each student in real time. This ability directly answers the challenges in teaching English, especially in the aspect of reading, which requires precise understanding of text structure, vocabulary, and meaning inference. This is in line with the idea of intelligent tutoring systems (ITS), where deep learning acts as an adaptive learning machine that independently learns from user interaction patterns and adjusts material presentation strategies (Sun et al., 2023).

This research emphasizes that deep learning-based reading learning in the era of digital transformation is not just a technological trend, but a strategic solution in answering learning gaps that occur due to differences in students' abilities. These results are reinforced by findings (Liang et al., 2023) which report that the application of AI-based learning systems in reading skills has a

significant impact on improving student literacy in secondary school. This research also corroborates a study by (McCarthy & Yan, 2024) which found that AI-powered reading tutors are able to accelerate the improvement of reading comprehension through user response-based interventions.

In the context of Indonesia as a developing country, the integration of deep learning in English learning is also an important strategy to strengthen the competitiveness of the younger generation in the era of digital globalization. Most teachers and students in urban areas are now familiar with digital devices, but have not fully utilized AI-based technology in the teaching and learning process. Therefore, the findings of this study practically pave the way for the development of an English curriculum based on adaptive technology that is in accordance with the principles of Freedom of Learning, as well as supporting students' digital literacy achievements.

Although the results of this study show high effectiveness, there are several factors that determine the success of implementation. Teachers' readiness to integrate technology into teaching strategies is an important factor. (Ju, 2023) highlights that one of the biggest challenges in the application of AI in the classroom is the pedagogical limitations of teachers in making optimal use of adaptive features. In this study, intensive training for teachers was carried out as part of the intervention, which was proven to support the effectiveness of program implementation. In addition, infrastructure factors, such as the availability of devices and internet connections, are also technical constraints that need attention in replication or scaling up programs.

The theoretical contribution of this study lies in mapping the effectiveness of deep learning in learning reading skills, especially at the elementary-secondary education level which has so far received less attention in AI-based studies. Meanwhile, practically, this study offers an early model of the application of adaptive systems in English teaching that can be further developed for other language skills such as writing and speaking. This research also opens up opportunities for the design of English learning that is multimodal and systemically integrated in the national e-learning platform.

CONCLUSIONS AND RECOMMENDATIONS

This study empirically proves that the integration of deep learning technology in English reading learning has a significant positive impact on improving the reading comprehension skills of junior high school students in the era of digital transformation. Through a quantitative approach with a quasi-experimental design of a nonequivalent control group, data was obtained showing that the experimental group that learned using a deep learning technology experienced a much higher increase in post-test scores than the control group that learned with conventional methods. The N-Gain analysis also reinforced the effectiveness of this approach by showing a moderate-high improvement category for the experimental group.

These findings confirm that the application of deep learning technology is not only able to improve learning outcomes, but also has transformative implications for pedagogical approaches that have been static. Personalized,

data-driven, and adaptive learning allows the learning process to be more contextual and responsive to students' individual needs. This research makes a theoretical contribution to the development of an artificial intelligence-based English learning model and provides a practical foundation for teachers and policy makers to design teaching strategies that are relevant to the development of educational technology in the digital era.

ADVANCED RESEARCH

Future research should advance this study by exploring longitudinal effects of deep learning technology on students' literacy development across diverse educational levels, integrating multimodal data such as eye-tracking, behavioral analytics, and real-time feedback to capture deeper cognitive processes in reading comprehension. Comparative studies between deep learning and other AI-based adaptive learning systems, such as reinforcement learning or natural language processing-driven platforms, could provide broader insights into their relative effectiveness. Moreover, examining teachers' readiness, pedagogical adaptability, and institutional support is crucial to ensure sustainable implementation. Expanding the scope to cross-cultural or international contexts would also enrich the theoretical framework and validate the generalizability of AI-based English learning models in addressing the challenges of global digital education.

REFERENCES

- Astri, N., Ramadhan, A. P., & Lestari, D. (2024). The impact of digital learning engagement on EFL learners' critical reading comprehension. *International Journal of English Education*, 12(1), 45–59. <https://doi.org/10.24036/ijee.v12i1.2024>
- Cohen, L., Manion, L., & Morrison, K. (2021). *Research methods in education* (8th ed.). Routledge. <https://doi.org/10.4324/9781315456539>
- Creswell, J. W., & Creswell, J. D. (2023). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (6th ed.). Pearson Education.
- Field, A. (2022). *Discovering statistics using IBM SPSS statistics* (6th ed.). SAGE Publications.
- Fitriyani, A. (2022). Strategies for developing English reading skills for junior high school students. *Journal of Education and Language*, 14(2), 122–133. <https://doi.org/10.23887/jpb.v14i2.2022>
- Hartanto, D., Lestari, R., & Wibowo, M. E. (2021). Adaptive learning for online learning based on artificial intelligence. *Journal of Indonesian Educational Technology*, 13(3), 200–213. <https://doi.org/10.21009/jdpi.v13i3.2021>
- Ju, H. (2023). Examining the limitations of AI integration in K-12 education: A critical approach. *Journal of Artificial Intelligence in Education*, 33(1), 55–78. <https://doi.org/10.1007/s40593-023-00306-8>
- Liang, X., Hu, Y., & Zhang, J. (2023). Adaptive reading instruction using deep learning models in middle school classrooms. *Computers & Education*, 192, 104661. <https://doi.org/10.1016/j.compedu.2023.104661>

- Mariani, R., Putra, R. A., & Hidayat, M. (2023). Adaptive learning and AI-assisted instruction in English classrooms: The future of reading comprehension. *TESOL International Journal*, 14(2), 78–95. <https://doi.org/10.3390/tesol.v14i2.2023>
- McCarthy, J., & Yan, Z. (2024). The effectiveness of AI-powered reading tutors: An empirical investigation. *Educational Technology Research and Development*, 72(1), 33–56. <https://doi.org/10.1007/s11423-024-10335-2>
- Nation, I. S. P. (2020). *Teaching ESL/EFL reading and writing* (2nd ed.). Routledge. <https://doi.org/10.4324/9780429276079>
- Nugroho, B., & Triana, R. (2021). PISA 2018 and the urgency of improving the quality of literacy in Indonesia. *Journal of Educational Evaluation*, 25(2), 101–114. <https://doi.org/10.21831/jev.v25i2.2021>
- Putra, B. Y., & Nugroho, A. (2021). The application of deep learning-based chatbots to support online learning. *Journal of Information Technology and Education*, 14(1), 45–56. <https://doi.org/10.24036/jtip.v14i1.2021>
- Rahmawati, D. (2023). Digital-based English learning transformation in the society 5.0 era. *Journal of Educational Innovation*, 17(1), 88–97. <https://doi.org/10.21009/jip.v17i1.2023>
- Sugiyono. (2022). *Quantitative, qualitative, and R&D research methods*.
- Sun, X., Yang, M., & Liu, H. (2023). Deep learning in English reading instruction: An adaptive system model based on CNNs. *Journal of Educational Computing Research*, 61(4), 876–893. <https://doi.org/10.1177/07356331231101652>
- Tri Astuti, A. (2025). Analysis of teacher readiness in the integration of AI in English teaching. *Journal of Language Education*, 15(1), 33–44. <https://doi.org/10.21831/jpb.v15i1.2025>
- Wang, Y., Zhou, Z., & Liu, Y. (2023). Intelligent reading instruction using ChatPRCS: A personalized AI-based system for improving EFL reading comprehension. *International Journal of Artificial Intelligence in Education*, 33(2), 123–143. <https://doi.org/10.1007/s40593-023-00312-y>
- Warschauer, M., & Liaw, M. (2020). Emerging technologies for autonomous English language learning. *Language Learning & Technology*, 24(3), 1–15. <https://doi.org/10.125/44782>
- Wulandari, S., & Kurniawan, A. (2022). AI-based reading recommendation system for improved understanding of English texts. *Journal of Technology and Learning*, 10(2), 101–115. <https://doi.org/10.21009/jtp.v10i2.2022>
- Zhou, L., Qian, M., & Tang, X. (2022). Personalized learning with deep neural networks: Applications and implications. *Journal of Educational Technology Development and Exchange*, 15(1), 25–42. <https://doi.org/10.18785/jetde.1501.02>