

The Impact of AI-Driven Scaffolding on Learning Loss and Autonomy in Eleventh Graders

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Abstract

The study aimed to investigate the impact of AI-driven education in implementing a scaffolding strategy which was based on AI in addressing educational loss and enhancing autonomy among eleventh grade students in Palestine. A quasi-experimental approach was employed, with the study population comprising all eleventh-grade students. The sample included (45) female students, divided into two groups: an experimental group of (22) students and a control group of (23) students. An English language skills tests and an autonomy scale were developed and administered pre- and post- intervention. A one-way Analysis of Covariance (ANCOVA) was performed to analyze the scores of students for both instruments. The results revealed significant differences in the responses of the participants on the English language skills tests, favoring the experimental group according to the the adjusted mean scores for each group. Additionally, there were statistically significant differences on the autonomy scale, also in favor of the experimental group as the the adjusted mean scores for each group. These findings underscore the effectiveness of implementing scaffolding strategy which was driven by AI in both mitigating educational loss and fostering autonomy among eleventh-grade students. The researcher recommends establishing policies that integrate AI-driven scaffolding strategies into regular classroom instruction to enhance learner autonomy and address skills deficits. Policymakers should develop a national framework that plan and then apply AI-based scaffolding strategy to address the learning gaps. Stakeholders should conduct longitudinal studies to examine the sustained impact of AI-driven scaffolding on learner autonomy and recovery in diverse educational settings.

Keywords: AI-driven education, scaffolding, educational loss, autonomy, eleventh grade

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Introduction

AI has become the tool used to penetrate the existing area of society and interfere with different segments to become the post-industrial development of many sections influencing and changing human lives (Konecki & Biškupić, 2023; Vacarelu, 2023). AI is also likely to cause a significant disruption on the education industry where universities and other institutions have started applying AI in instructional a learning, assessment, administrative and research activities to get the best results (Hwang et al., 2020). However, together with desire, the implementation of AI in higher Learning assumes a phenomenon of a set of advantages and disadvantages that require further research (Leoste et al., 2021).

Based on the article by Hsiao and Chang (2023), it is evident that the AI utilization could be employed as the learning technique that could ease the pressure focused in the teacher and student as well as increase the amount of learning. Combined with the current trends in education such as the digitalization of resources, game adaptation and learning personalization AI offers a great number of advancement opportunities. For instance, the profile making models have been used systematically to develop reactive and adaptive tutorials for promoting pl and as a way of dealing with teacher availability through ITS (Hsiao & Chang, 2023). These ITSs offer personalized learning experiences in four key ways: copying student inputs, distributing the proper tasks, providing feedbacks and outlining the manners in which learner will interact with the computer (Dai et al., 2020).

In the context of using artificial intelligence in education, it is clear to conclude that the use of Technologies of artificial intelligence adds views on how the teaching and learning processes can be innovated. The Intelligent tutoring systems and others can help instructors to reduce their workload by performing some of those tasks on behalf of the instructors, further, delivering unique learning process for each learner and offering immediate response and evaluation for the learners. On the same note, the possibility of using AI solutions in education can by no means negate the problem of the educational crisis, let alone such extrinsic factors as the COVID-19 and economical volatility. Although the various types of AI are helpful for maintaining continuity and increasing the engagement of learning, society must realize how disrupted learning is due to the pandemic.

In the last few years, the existing educational system in Palestine failed to overcome several hurdles due to external factors even though the worst was the COVID-19 pandemic. Even from the start of the year, the students have not been able to learn consecutively for an entire year calendar and school due to disruptions from the pandemic affecting accumulation of learning loss. These interruptions have in combination with the control of the economy, teachers' strikes, and regional conflict led to deteriorations in the fundamental language skills such as reading, writing, speaking and listening. Further, the student struggles in understanding knowledge area like grammar, factual knowledge resulting to slow progress.

As a consequence of these cumulative factors, students have experienced a decline in essential language skills, particularly in the four key areas of language acquisition: comprehension which include, reading, writing, speaking and listening. This has not only affected grammatical competence, but also the growth of the students' vocabularies as well as their general fluency of speech. The incorporation of blended learning, which was supposed to help learners maintain continuity, has more frequently failed to address the learners' needs in an effective manner and thus has served to exacerbate learners' decline of their linguistic abilities. This kind of educational loss—lost in a number of ways simultaneously—

underscores the need to now intervene to ameliorate these deficits in order to help children get back to where they need to be.

To mitigate the effects of previous interruptions on successful formative teaching, many strategies can be employed to improve students' performance and their language abilities. Consequently, it is evident that homework assignments, periodic quizzes, and diagnostic exams are essential for providing practice beyond the classroom and identifying areas that want further intervention. Furthermore, when the working group addressed various tasks and the application of IT technologies in pedagogical practices, student engagement may be enhanced due to the emphasis on an active teaching-learning process, which would motivate students to study. The management of group classes, peer engagement, and constructive feedback revitalizes students' motivation and facilitates language acquisition (Munawar, 2019).

Scaffolding is a highly regarded approach for mitigating educational loss, as it offers pupils a comprehensive foundation for incremental learning. This strategy enables educators to develop instructional strategies that align with individual students' learning requirements while also promoting independence and self-motivated learning methods. The scaffolding technique empowers students to enhance their linguistic proficiency in reading, writing, grammar, and vocabulary, while also augmenting their confidence in the language employed. In the present research, the preferred methodology will analyze the possibility of using the AI-driven education in the realization of the scaffolding strategy as one of the methods to reduce educational loss alongside increasing English language skill proficiency in students (Narina, 2022).

Vygotsky's sociocultural theory (1978) of the scaffolding method refers to how much support is given to a student till he has sufficient strength to keep the process by himself and be more self-conducted in the classroom setup. With the assistance of modern AI devices, teachers will be capable of successfully addressing the needs of students in the educational framework and producing learning content and products together with improving problem-solving capabilities. Therefore, this study will focus on the creation of awareness of the two-in-one solution policy of increasing augmented integrated AI to do away with educational loss and maximize the autonomy of students.

Statement of the Problem

The educational loss in Palestine is caused by a number of reasons/factors that are interconnected. These factors include poverty, poor infrastructure, and resource inaccessibility. Moreover, the education system has also been affected greatly by the occupation, as the schools have been closed and limits are imposed. Bsharat et al. (2024) add political instability and occupation to the list of mammoth obstacles in the way of the effective provision and use of educational resources. This instability harms both students and teachers and makes it impossible to bring about long-term plans in educational development. Adding to this problem is the condition of the educational infrastructure that tends to be outdated, is overcrowded, and does not contain modern technology (Hussein et al., 2024). This paper examines the role of AI-based scaffolding techniques and support to reduce such losses and promote independence. In particular, it aims at discussing the question of whether these strategies improve the language proficiency of students and their learning autonomy.

Hypothesis of the Study

Hypothesis 1: There are no statistically significant differences at the significance level ($\alpha \leq 0.05$) between the responses of the experimental group and the control group on the English language skills test attributed to the teaching method (scaffolding strategy vs. traditional method).

Hypothesis 2: There are no statistically significant differences at the significance level ($\alpha \leq 0.05$) between the responses of the experimental group and the control group on the Autonomy Scale attributed to the teaching method (scaffolding strategy vs. traditional teaching).

Objectives of the Study

- 1- To evaluate the impact of AI-driven scaffolding strategies in mitigating educational loss among eleventh-grade students.
- 2- To assess the impact of these strategies on enhancing students' autonomy in learning.

Significance of the Study

This study is significant for several reasons:

1. It contributes to the body of knowledge on AI applications in education, particularly in addressing educational loss and fostering autonomy.
2. It provides practical insights for educators and policymakers on implementing scaffolding strategies in secondary education.
3. It aids in designing interventions that support students' recovery from educational disruptions while preparing them for self-directed learning.

Limitations of the Study

- Population: Eleventh-grade students in Palestine
- Place: Farahat secondary school /Bethlehem Directorate
- Time: The study is conducted over the first semester of the academic year (2024/2025)

Study Terms

Scaffolding strategy: A teaching method that involves providing tailored support to students to help them achieve learning objectives and gradually transferring responsibility to the students. Alrawili et al. (2020) stated that it refers to

temporary support or assistance, provided by a teacher, peer, parent, or computer, that permits a learner to perform a complex task or process that he or she would be unable to do alone -- the technique builds knowledge/skills until learners can stand on their own, similar to scaffolding on a building.

AI-Driven education refers to integrating artificial intelligence technologies into educational systems to enhance learning experiences and outcomes. These systems use data-driven algorithms, adaptive learning environments, and intelligent tutoring to tailor educational content to individual needs, automate repetitive tasks, and offer real-time feedback. AI in education also supports decision-making, facilitates resource allocation, and fosters

personalized teaching methods, addressing diverse student abilities and challenges. This approach enhances accessibility and efficiency across educational frameworks (IEEE Xplore, 2024).

Educational loss refers to Educational loss is described as the negative impact on students' learning outcomes and skill development due to disruption in the schooling process such as school closure periods, disasters, or lack of sufficient educational opportunities. This situation can greatly affect the educational advancement, the mental wellbeing and even future productivity. The COVID-19 crisis exposed these problems quite vividly, especially in poorly endowed areas where the lack of online education availability worsened the already existing inequalities (Meinck et al., 2022; UNICEF, 2022).

Autonomy: The ability of students to take charge of their own learning including setting goals, managing time, and evaluating their progress. In an educational context, autonomy is often linked to a student's ability to take responsibility for their own learning, make decisions about what and how they learn, and engage in self-directed activities (Deci & Ryan, 2000).

Eleventh grade is part of the secondary education system in Palestine (16-17 year old students). It is the schoolastic year that precedes Tawjihi in which students take the General Education Certificate Examination. During this year, students specialize in tracks such as scientific, literary, or vocational streams. The eleventh grade aims to prepare students for their final year of secondary education, influencing their higher education and career decisions (Ministry of Education, Palestine, 2020).

Study Results

This section presents the results of the study based on the research questions aimed at examining the impact of scaffolding strategy driven by AI on improving English language skills and enhancing autonomy. Below are the findings of the study.

1. Results Related to the First Hypothesis:

Hypothesis (1): There are no statistically significant differences at the significance level ($\alpha \leq 0.05$) between the responses of the experimental group and the control group on the English language skills test attributed to the teaching method (scaffolding strategy vs, traditional method)

To test this hypothesis, the means and standard deviations of the responses from the experimental and control groups were calculated, as shown in Table (1):

Table 1

Means and Standard Deviations of the Experimental and Control Group Students' Scores on the Pre-test and Post-test for English Language Skills

Group	Students No.	Pre- test		Post- test	
		Mean	Standard Deviation	Mean	Standard Deviation
Experimental	22	27.87	14.67	45.77	15.42
Control	23	28.64	14.43	929.6	8.81

It is evident from Table (1) that the mean scores for the responses of both groups on the post-test of English language skills were (45.77) for the experimental group and (29.69) for the control group, with standard deviations of (15.42) and (8.81) for the experimental and control groups, respectively. To determine the differences in favor of either group, a one-way Analysis of Covariance (ANCOVA) was conducted after controlling for the pre-test effect, as shown in Table (2):

Table 2*ANCOVA Analysis of Student Performance on English Language Skills Test*

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Pre (covariate)	5233.586	1	5233.586	173.457	.000
Groups	2607.980	1	2607.980	86.436	.000
Error	1267.235	42	30.172		
Total	73234.000	45			
Corrected Total	9313.644	44			

It is shown in Table (2) that there were statistically significant differences at the ($\alpha \leq 0.05$) significance level between the scores of the experimental and control groups on the English language skills test. F value was (86.436) and the significant level was (.000). Signifying that rejecting the null hypothesis and accepting the alternative one. To determine the source of these differences, table (3) below shows the adjusted mean scores for each group.

Table 3*Estimated Marginal Means*

The two groups	Mean	Std. Error
Control group	30.24	1.15
Eperimental Group	45.48	1.17

As shown in the table, the differences favored the experimental group, which was taught using the scaffolding strategy driven by AI, as it obtained a higher mean score of (45.48) compared to the control group with(30.241) as a mean score.

2. Results Related to the Second Hypothesis:

Hypothesis (2): There are no statistically significant differences at the significance level ($\alpha \leq 0.05$) between the responses of the experimental group and the control group on the Autonomy Scale attributed to the teaching method (scaffolding strategy vs. traditional teaching).

To test the second hypothesis, the means and standard deviations of the responses from the experimental and control groups were calculated, as shown in Table (4):

Table 4

Means and Standard Deviations of the Experimental and Control Group Students' Scores on the Pre-test and Post-test for the Autonomy Scale

Group	Students No.	Pre- test		Post- test	
		Standard Deviation	Mean	Standard Deviation	Mean
Experimental	22	0.94	2.55	0.71	3.95
Control	23	0.63	2.14	0.77	2.39

It is evident from Table (4) that the mean scores for the responses of both groups on the post-test of the Autonomy Scale were (3.95) for the experimental group and (2.39) for the control group, with standard deviations of (0.71) and (0.77) for the experimental and control groups, respectively. To determine the differences in favor of either group, a one-way Analysis of Covariance (ANCOVA) was conducted after controlling for the pre-test effect, as shown in Table (5):

Table 5

ANCOVA Analysis of Student Performance on the Autonomy Scale

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Pre (covariate)	.256	1	.256	.467	.498
Groups	5.609	1	5.609	10.245	.003
Error	22.994	42	.547		
Total	439.726	45			
Corrected Total	37.003	44			

It is shown in Table (5) that there were statistically significant differences at the (0.05) significance level between the scores of the experimental and control groups on the Autonomy Scale; F value was (10.25) and the significant level was (0.003). That is to say, rejecting the null hypothesis and accepting the alternative one. To identify the source of these differences, table (6) below shows the adjusted mean scores for each group.

Table 6
Estimated Marginal Means

The two groups	Mean	Std. Error
Control group	2.52	0.18
Experimental Group	3.49	0.19

The data in the table indicate a preference for the experimental group, which was taught using the scaffolding strategy which was driven by AI, as it obtained a higher mean score of (3.49) compared to the control group with (2.52) as a mean score.

Discussion of the Results

This section presents a comprehensive analysis of the study's findings, contextualises them within the framework of relevant literature. Each research question is addressed individually, summarizing key results and contrasting them with findings from previous studies. This synthesis highlights similarities and discrepancies, providing a nuanced understanding of how this study contributes to the field of scaffolding strategies in education.

Results for the Impact of Scaffolding Strategy on English Language Skills

The study's findings indicate a statistically significant improvement in the English language skills of students in the experimental group, who were taught using the AI-driven scaffolding strategy, compared to the control group, which followed traditional teaching methods. The post-test mean score for the experimental group was notably higher, reflecting enhanced performance in all four key areas of language acquisition: reading, writing, listening, and speaking. This suggests that the scaffolding strategy, supported by AI, provided tailored guidance and adaptive learning experiences, enabling students to overcome their language learning challenges effectively.

A deeper analysis reveals that this improvement is attributable to several factors inherent to the scaffolding strategy. Firstly, the incremental learning approach, where tasks are broken down into manageable steps, likely helped students gradually build their language competencies. Secondly, the AI component ensured personalized feedback and adaptive learning paths, addressing individual needs and pacing the instruction to match each student's proficiency level. This synergy between scaffolding and AI likely created an optimal learning environment, fostering both engagement and mastery.

Those findings align with and build upon existing literature that underscores the effectiveness of scaffolding strategies in enhancing language skills. While Clark and Graves (2005) discussed in their research highlighted that structured scaffolding significantly improves comprehension skills during reading activities. This study corroborates those results by demonstrating similar enhancements in comprehension as part of the broader improvements in reading skills among the experimental group.

In addition, Ahmadi Safa and Motaghi (2024) reported that scaffolding strategies significantly improved listening comprehension in EFL contexts. The current study supports this by showing how scaffolding effectively bolstered listening abilities, likely due to guided

listening exercises and immediate AI-generated feedback tailored to the students' comprehension gaps.

Also, Hsiao and Chang (2023) emphasized the potential of intelligent tools in personalizing learning experiences and enhancing grades and assignment quantity. The Integration of AI-driven scaffolding in this study resonates with those findings, particularly in providing adaptive tasks, real-time feedback, and tailored recommendations. These features likely contributed to the students' improved proficiency across all skill areas.

While previous studies have explored scaffolding or AI in isolation, this study contributes uniquely by combining the two approaches. The use of AI amplifies the traditional scaffolding framework by automating feedback mechanisms, ensuring precise and timely guidance, and dynamically adjusting instructional content based on individual performance. This integration addresses the practical limitations of manual scaffolding, such as time constraints and variability in teacher expertise, thereby extending the applicability and efficiency of scaffolding strategies in classroom settings.

Moreover, the current study demonstrates the scalability of AI-driven scaffolding, making it feasible to implement in diverse educational contexts. This scalability is particularly significant in settings where language learning gaps are pronounced, as seen in the Palestinian education system, which has faced disruptions due to external challenges.

The findings underscore the potential of AI-enhanced scaffolding strategies in language education, especially in contexts where traditional teaching methods fall short in addressing individual learning needs. Future research could investigate the long-term effects of this approach on language retention and explore its application in other subject areas or different educational levels. Additionally, further studies might focus on optimizing the AI component to ensure culturally and contextually relevant feedback, enhancing its effectiveness across diverse learner populations.

Results for Enhancing Autonomy Through Scaffolding Strategy

The study's results demonstrated a statistically significant increase in autonomy among the experimental group. This indicates that the scaffolding strategy driven by AI effectively fostered self-directed learning. Students in the experimental group displayed greater independence in managing their learning activities, making decisions, and solving problems without direct intervention from the teacher. This increase in autonomy reflects the scaffolding approach's ability to gradually transfer responsibility from the educator to the learner, allowing students to take ownership of their educational journey. The AI component amplified this effect by providing real-time feedback, personalized learning pathways, and adaptive guidance, which encouraged students to engage actively in their learning processes. By addressing individual learning needs, the scaffolding strategy also likely reduced the cognitive load on students, enabling them to approach tasks more confidently and independently.

The findings that align with and build upon existing literature emphasizing how Scaffolding Strategy effectively enhance learner autonomy. Cortázar et al. (2021) highlighted in their findings the potential of scaffolding to promote critical thinking and learner autonomy. The current study aligns with this conclusion, demonstrating that scaffolding not only supports

knowledge acquisition but also empowers students to approach learning tasks with greater independence.

In addition, Vygotsky's Zone of Proximal Development (ZPD) in his theoretical framework (1978) underpins the scaffolding strategy, emphasizing that autonomy is achieved through guided learning that gradually shifts responsibility to the learner. The results align with this theory, as students in the experimental group moved from dependent to independent learning behaviors during the intervention.

Simultaneously, Alavi and Esmailifard (2021) highlighted that scaffolding reduces language anxiety and fosters collaboration, which indirectly contributes to greater learner autonomy. Consistently, this study observed that students taught using the AI-driven scaffolding strategy showed higher confidence and self-reliance, which are critical components of autonomy.

The findings contrast with Chen and Law (2016), who argued that real-time "soft scaffolding" (adaptive, immediate teacher support) is essential for enhancing autonomy. According to their study, while pre-designed "hard scaffolding" (structured, pre-planned support) offers foundational guidance, it lacks the flexibility to address real-time learning challenges. This suggests that while the AI-driven scaffolding strategy in this study was effective, incorporating real-time teacher interventions alongside AI could further enhance learner autonomy.

Results for Addressing Educational Loss Through Scaffolding Strategy

The study demonstrated that the AI-driven scaffolding strategy effectively mitigated educational loss. Students in the experimental group exhibited marked improvements in their English language skills, recovering from the deficits caused by disruptions such as the COVID-19 pandemic. The scaffolding strategy provided incremental learning opportunities that enabled students to rebuild foundational skills in reading, writing, listening, and speaking.

AI played a crucial role by delivering personalized interventions and adapting learning tasks to the needs of each student. This targeted approach likely accelerated the recovery process by addressing specific areas of weakness and enabling students to regain lost competencies.

Pier et al. (2021) emphasized the importance of targeted interventions in combating learning loss during extended disruptions. The current study aligns with these findings, demonstrating that scaffolding strategies, especially when integrated with AI, can effectively address educational loss caused by crises.

In addition, Dai et al. (2020) highlighted the adaptability of AI tools in education, particularly their ability to provide immediate feedback and tailored learning experiences. This study reinforces their conclusion, showing how AI-driven scaffolding effectively supported students in regaining lost learning.

On the contrary, Eglitis et al. (2024) identified long academic breaks as a significant factor in educational loss but proposed recovery strategies that relied on traditional instructional methods. Unlike these strategies, the current study emphasizes the use of innovative, AI-enhanced scaffolding, which proved more effective in addressing complex learning disparities in a shorter time frame.

From the evidence presented, this study provides a significant contribution to the existing literature by demonstrating the dual impact of AI-driven scaffolding on learner autonomy and educational recovery. It bridges key gaps by offering innovative insights into integrating AI as a dynamic scaffolding tool and addressing contemporary educational challenges.

Key Contributions

1. **Integration of AI and Scaffolding:** Building on Vygotsky's concept of the Zone of Proximal Development (ZPD) (1978), the study incorporates AI as a flexible and responsive scaffolding mechanism. This integration not only enhances learner autonomy but also supports skill recovery in a more personalized manner.
2. **Addressing Contemporary Challenges:** The study directly tackles the learning loss exacerbated by the COVID-19 pandemic, offering timely and practical applications of scaffolding strategies to mitigate educational setbacks in real-world crises.
3. **Practical Implications:** Findings suggest that combining pre-designed scaffolding frameworks with real-time, adaptive interventions can significantly enhance learning outcomes. This paves the way for more effective and scalable education strategies across diverse contexts.

Recommendations

1. Establish policies that integrate AI-driven scaffolding strategies into regular classroom instruction to foster autonomy and skill development.
2. Combine structured scaffolding with real-time adaptive interventions to maximize educational outcomes.
3. Develop teacher training programs to effectively implement and monitor AI-enhanced scaffolding tools.
4. Investigate the role of individual learner characteristics, such as prior knowledge and learning preferences, in moderating the effectiveness of AI-driven scaffolding strategies.
5. Explore the incorporation of real-time "soft scaffolding elements to refine the adaptability and responsiveness of AI tools.
6. Policymakers should develop a national framework that plan and then apply AI-based scaffolding strategy to address the learning gaps.
7. Stakeholders should conduct longitudinal studies to examine the sustained impact of AI-driven scaffolding on learner autonomy and recovery in diverse educational settings.

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