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From Struggle to Script: Enhancing Reading and Writing in Palestinian Special Education Through Artificial Intelligence

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Abstract. Students with a learning disability frequently find it difficult in achieving the primary skills of literacy, especially in an under-resourced context such as Palestine. With the structure of traditional instruction, few are those able to address the learning needs of exceptional children, creating an opportunity for some sort of technological intervention. The present study analyzed the impact of AI-based interventions on reading and writing skills for students with learning disabilities. Using a mixed-method quasi-experimental approach, the study combined quantitative pre-tests and post-tests with qualitative reflections on attitudes and motivation. A total of 79 students, enrolled in two private schools in Jerusalem, aged between 8 and 12 years old participated. The participants were assigned randomly to one of four groups: three experimental intervention groups and one control group receiving conventional instruction. Data collection consisted of standardized literacy assessments, behavioral checklists, and an attitude scale after the intervention. Quantitative data analyses were done using t-tests, one-way analysis of variance, and effect-size calculations. The findings revealed statistically significant enhancements in both reading and writing skills, across the three experimental groups, with the biggest gains due to the use of the adaptive AI tools ($p < .01$). There appeared to be no gender-based differences in the raw scores. Qualitative feedback highlighted the increase in motivation among students. These results demonstrate the pedagogical value of AI applications in special education and support their integration into individualized literacy instruction. The study further emphasizes the need for scalable, culturally relevant, and ethically-grounded AI solutions.

Keywords: Artificial intelligence; learning disabilities; reading skills; writing skills

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1. Introduction

Learning disabilities (LD) remain one of the most pressing challenges within educational systems, particularly due to their impact on core skills such as reading and writing. These challenges hinder students' academic progress and cognitive development. With the advancement of artificial intelligence (AI), new educational tools have emerged that offer promising interventions for students with LD. However, studies evaluating the effectiveness of such applications in Palestine remain limited. This study aimed to address that gap by exploring how AI can enhance educational practices for this population.

Reading skills are foundational to learning. Students with LD often struggle with decoding, comprehension, and symbol recognition. In Palestine, Bataineh (2021) reported that many LD students face significant difficulties in early reading skills. Similarly, Mihret and Joshi (2025) found a strong correlation ($r > 0.60$) between reading proficiency and academic achievement. The Palestinian Ministry of Education (2023) reported a notable decline in reading skills among early-grade students, emphasizing the need for innovative, individualized interventions.

Writing presents parallel challenges. Graham et al. (2014) noted persistent difficulties in written expression among students with LD, especially in organizing ideas and maintaining coherence. Recent reviews linked writing difficulties to reduced motivation and self-esteem (Gkora & Karabatzaki, 2023). In 2022, the Palestinian Literacy and Numeracy National Assessment Study similarly identified wide gaps in spelling, fluency, and expression among primary students (Palestinian Ministry of Education, 2022).

Technologies powered by AI have gained attention for their role in personalized learning. Ayeni et al. (2024) found that AI-powered adaptive platforms improved engagement and academic performance among LD students. Similarly, Evmenova et al. (2024) demonstrated that generative AI tools, such as ChatGPT, can complement teacher feedback and improve writing outcomes. Globally, the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2023) has advocated for AI's role in making education systems more inclusive, particularly for students with disabilities.

In Palestine, the urgency is heightened. Nearly 14.7% of primary students have diagnosed LD, primarily in reading and writing (Palestinian Ministry of Education, 2023). According to Qaddumi et al. (2023), and supported by field observations, traditional methods often fail to accommodate individual needs or integrate digital tools effectively due to infrastructure and training gaps. Recent assessments show that 42% of students fall below reading standards and 48% fall below writing standards. National initiatives, such as the Sixth Palestinian Educational Conference and a 2023 AI workshop at the Islamic University of Gaza, have called for integrating AI into early intervention strategies (Palestine Technical University – Kadoorie, 2018; Islamic University of Gaza, 2023).

This study investigated how various AI applications can improve the reading and writing abilities of students with LD in Palestinian schools.

1.1 Research Questions

1. What is the impact of AI applications on improving reading skills among students with learning disabilities?
2. What is the impact of AI applications on improving writing skills among students with learning disabilities?
3. Are there significant gender-based differences in the impact of AI on literacy skills?
4. Do different types of AI applications (interactive, adaptive, simulation-based) yield varying impacts on literacy outcomes?
5. What framework can be proposed for using AI to enhance literacy skills among students with learning disabilities?

1.2 Research Hypotheses

H1 No significant difference exists in reading test scores between the experimental (AI) and control (traditional) groups.
H2 No significant difference exists in writing test scores between the two groups.
H3 No significant gender-based differences exist in reading skill improvement.
H4 No significant gender-based differences exist in writing skill improvement.
H5 No significant differences exist in reading outcomes based on the type of AI application used.
H6 No significant differences exist in writing outcomes based on the type of AI application used.

This study investigated the impact of using AI applications on enhancing reading and writing skills among students with LD in Palestinian schools. Specifically, it examined the effects of AI tools on reading proficiency, writing ability, and potential gender-based differences in outcomes. Additionally, the study explored how different types of AI applications (interactive, adaptive, and simulation-based) differentially influence literacy skills, and proposed a framework for their effective use in special education. The research focused on students aged 8 to 12 years old who have been formally diagnosed with LD and are enrolled in private schools in the Jerusalem Governorate. It was conducted during the second semester of the 2025/2026 academic year, employing a quasi-experimental design with four groups (three experimental and one control), using both pre-tests and post-tests to assess the outcomes.

2. Literature review

Students with LD frequently exhibit incongruity between their cognitive potential and actual academic achievement. These discrepancies often stem from deficits in areas such as attention, memory, visual and auditory perception, and information processing speed (Al-Qahtani, 2022). In the context of literacy, these deficits manifest in difficulties with phonemic awareness, decoding, spelling, reading comprehension, and written expression. Ashcroft et al. (2023) demonstrated that visual perception and executive function deficits are key predictors of poor

writing performance, including spelling errors, disorganized sentence structure, and weak coherence in text production.

Reading and writing are central to students' academic success and lifelong learning. Reading encompasses not just symbol recognition and pronunciation but also the ability to interpret, evaluate, and synthesize information. Medranda-Morales et al. (2023) uncovered a strong relation ($r \approx .87$) between reading comprehension and the aptitude for critical thinking in high school students, which signifies the immense cognitive load that reading imposes. In a similar manner, writing equally blends mechanical and expressive tasks. It includes the ease of handwriting, adherence to grammar, as well as vocabulary and narrative organization. Examining the data of more than 4,900 middle school students, Skar et al. (2022) observed that the speed of handwriting predicted writing quality independently of other variables such as the students' languages, their gender, or even their classes.

New AI technologies open up new opportunities in special education. The term AI is defined as a computer system design that can mimic human tasks such as speech processing, pattern recognition, and learning adaptation. Salas-Pilco et al. (2022) demonstrated that special education has become enriched through intelligent tutoring systems, adaptive learning platforms, and assistive communication devices. In regions that implemented the use of AI tools, such as East Asia and Saudi Arabia, special education students showed immense progress in academic achievement, engagement, and the level of personalized instruction, validating the use of such methods.

Yap et al. (2025) gathered 84 studies and considered them from multiple perspectives. Yap et al. (2025) noted that reading aloud, eye tracking, and natural language processing tools based on AI notably enhance reading fluency, phonemic awareness, and comprehension. Educators with dyslexia experienced the most dramatic changes as they benefitted from immediate assistance from AI tools which dramatically outperformed traditional strategies. Concerning the advancements in writing, Goldman et al. (2024) reported that AI-based instruction improved spelling, text structuring, and expressive fluency. Kambouri et al. (2023) provided supporting evidence, explaining that the integration of speech-to-text tools in teaching not only quickened student writing but also increased the quantity of written work by almost 58%, along with enhancing student motivation and self-efficacy.

Various learning theories attempt to describe the methodology integrated into AI in special education. For instance, the cognitive theory of learning interprets learning as the process of obtaining and organizing information. AI can greatly enhance learning aids, not just by assisting in the focusing of attention but also by boosting the retention of information in working memory. Grasping a concept can also be made easier through multimodal inputs and instantaneous help. Alternatively, the differentiated instruction theory shows that teaching must be customized to students' preferred style of learning. Accordingly, AI fulfills this requirement by modifying the sequence of lessons, the pace, and the feedback in

accord with the students' wishes. The motivation theory, which is concerned with internal and external motivators, is also relevant: participation is driven by the gamified AI systems, various challenge levels, and instant rewards, and the outcomes of learning are enhanced. Marinelli et al. (2023) addressed the topic of interactive AI learning tools and serious games for children with LD in their study, arguing that these tools not only enhance the children's reading skills but also their AI-driven motivation and engagement.

While integrating AI into special education offers many benefits, it is not without challenges. Underfunded regions face a unique set of difficulties, including financial constraints, insufficient technological infrastructure, and unequal access to resources, which hamper the use of modern technologies. Moreover, the lack of AI software that supports the Arabic language and its pedagogical resources creates a great challenge for regions such as Palestine.

The issue of proper training of teachers is also relevant in this context: instructors who lack proper training in continuing professional development are less likely to have the competencies and confidence to integrate AI tools in their teaching practice. In addition, ethical issues emerge around three key issues: pupil privacy when data are used, clarity of the algorithm, and the degree of a human (teacher) involvement in decision-making. Considering these issues, Yan and Liu (2025) proposed an ethical framework for AI in education, comprising transparency, fairness, autonomy, and nonmaleficence.

Attitudinal research offers further insight in terms of special education and AI domains. Cukurova et al. (2023) established that teacher self-efficacy, trust in AI, and perceived usefulness predicted positive disposition towards AI. Conversely, major obstacles were lack of resources and fear over implementation. Ding et al. (2024) found that case-based, hands-on professional development programs greatly enhanced teachers' technical skills and pedagogical confidence with the employment of AI tools. Globally, there are various instances of AI being utilized in aiding students with special needs.

One such example is Finland's Digital School, which offers AI-supported lessons and also trains educators, school officials, and family members to help students. The UAE's Smart Reading Project focuses on developing literacy with AI tools adapted for the Arabic language, while Singapore's Smart Learning Program helps students address dyslexia and other learning difficulties with the help of personalized, adaptive AI platforms. Such examples prove that integration of services depends on technology, frameworks, design, collaboration, and strategic planning (CCE Finland, n.d; UAE government, 2023; GovTech Singapore, 2025).

In the future, the use of AI alongside other developing technologies can further develop the education sector and foster a great deal of innovation. For example, systems that track and analyze students' emotions can gauge their feelings and modify teaching materials accordingly to sustain and raise their interest and responsiveness. Internet-enabled smart classrooms can adapt to environmental factors such as lighting or sound to suit student preferences. Meanwhile, three

dimensional printers may be utilized to create tactile teaching aids for literacy for visually and cognitively challenged students. Salas-Pilco et al. (2022) emphasized that such combined approaches greatly guide education toward more personalized, accessible, and effective practices.

Literature on AI literacy tools unmistakably indicates that AI usage can improve reading and writing skills of children with LD. Such tools, when designed with users in mind, comprised effective teaching practices, and properly institutionally facilitated, can indeed surpass traditional approaches to literacy development. Thus far, challenges in realizing this potential because of systemic barriers in the form of cost, training, infrastructure, and cultural relevance need to be surpassed. In settings such as Palestine, where equity in education remains a critical issue, AI in special education presents a viable solution for transformative change if it is embraced in a responsible and well-considered manner.

3. Methodology

3.1 Research Design

The study used a mixed-method quasi-experimental design with equivalent groups, premised upon the presumption of pre-tests and post-tests to measure the value of AI applications in improving reading and writing skills among students with LD. The study employed this design since it was not possible to randomly assign treatment at an individual level in schools. Consequently, such equivalent grouping facilitated a legitimate comparison of treatment effects among students and preserved ecological validity in the natural classroom environment.

Among the available options, the quasi-experimental method best addressed the research objective as it permitted adjusting for pre-existing differences among groups and evaluating the causal effects of AI interventions in literacy. In addition, an integrated study design was implemented in which students' qualitative reflections were analyzed to understand the attitudinal and motivational dimensions of the intervention, thereby classifying the study as mixed methods.

Considering both of the methodologies, the study was able to evaluate the measurable effects of AI and the students' experiences in their own words, which described the intervention's impact in a more comprehensive manner. The study was conducted over the course of six weeks in the latter part of the 2025/2026 academic year. During this period, each group was provided with three sessions every week. The study took place in two private schools located in Kufr Aqab, north of Jerusalem, specifically Future Generation Primary School for Boys and Future Generation Secondary School for Girls.

Both schools are equipped with modern teaching technologies and with special resource rooms designed for LD students. To protect the integrity of the intervention, the researcher's involvement was restricted to coordinating with the schools for the submission of the instruments, tabulating the results, and training the teachers on AI applications. The researcher did not do any instruction so that the study remained neutral and unobtrusive.

3.2 Participants and Sampling Procedure

The study included 79 students (40 males and 39 females) from grades 3 to 5, purposefully selected from those formally diagnosed with LD and enrolled in the resource rooms. The participants were randomly assigned into four groups:

- Experimental Group 1 (interactive applications): 20 students
- Experimental Group 2 (adaptive applications): 20 students
- Experimental Group 3 (simulation-based applications): 20 students
- Control Group (traditional method): 19 students

3.2.1 Instruments and Data Collection Strategies

1. Reading Skills Test: Designed to assess letter and word recognition, fluency, and comprehension. The test was administered individually to all 79 participants in both pre-test and post-test phases, under the supervision of the resource room teachers. Each session lasted approximately 30 minutes to minimize fatigue and ensure reliable measurement.

2. Writing Skills Test: Assessed spelling, handwriting, and written expression. Students completed the test in classroom settings, with 20–25 minutes allocated for each administration. Both pre-tests and post-tests were conducted simultaneously across groups to avoid time-related bias.

3. Observation Checklist: Used to record students' behavioral performance during learning activities. The checklist was filled out by the classroom teachers after each instructional session across the six-week intervention period. Observed indicators included engagement, persistence, error correction, and peer interaction. To ensure reliability, teachers received prior training from the researcher on standardized observation procedures.

4. Attitudes Toward AI Scale: Administered to measure students' perceptions and attitudes following the intervention. The scale was given only once, at the conclusion of the six-week program, to all 79 participants. It consisted of 15 Likert-type items covering domains such as perceived usefulness, motivation, and ease of use. The administration was conducted in resource rooms under teacher supervision, and students requiring clarification were assisted individually.

The quantitative data were analyzed using means, standard deviations, one-way analysis of variance (ANOVA), independent samples t-tests, and effect size calculations.

4. Results

4.1 Demographic Characteristics of the Sample

Table 1 shows a balanced distribution of participants by gender and grade level across the four groups, supporting the internal validity of the experimental design.

Table 1: Distribution of participants by gender, grade level, and group

Variable	Control	Simulation	Adaptive	Interactive	Total
Males	7	6	7	7	27
Females	7	9	8	8	32
Grade 3	5	6	6	5	22
Grade 4	5	6	5	6	22
Grade 5	4	3	4	4	15

4.2 Quantitative Findings

Table 2: Pre-test and post-test differences in reading skills

Group	Pre-test mean	Post-test mean	t-value	Significance
Interactive	13.21	19.45	6.84	$p < 0.01$
Adaptive	13.67	20.12	7.21	$p < 0.01$
Simulation	13.55	18.94	5.96	$p < 0.01$
Control	13.48	14.33	1.08	Not significant

The data indicate statistically significant improvements in reading skills among all three experimental groups, whereas the control group showed no significant change, confirming the effectiveness of AI applications in reading development.

Table 3: Pre- and post-test differences in writing skills

Group	Pre-test Mean	Post-test Mean	t-value	Significance
Interactive	12.84	18.70	6.55	$p < 0.01$
Adaptive	13.02	19.42	7.12	$p < 0.01$
Simulation	12.90	17.88	5.88	$p < 0.01$
Control	13.10	13.86	1.14	Not significant

While these results suggest that the use of AI writing tools positively influences writing skills development, a marked difference emerged in the writing skills of experimental groups.

Table 4: One-way ANOVA—differences by type of AI application

Skill	Source	SS	df	MS	F	p-value
Reading	Between Groups	52.41	2	26.20	7.43	0.001 **
Writing	Between Groups	48.77	2	24.38	6.98	0.002 **

The ANOVA results indicate statistically significant differences in reading and writing improvements based on the type of AI application used. Adaptive applications yielded the highest effectiveness across both skill domains, underscoring the importance of tool selection.

Table 5: Independent samples t-test—post-test differences by gender

Skill	Gender	Mean	SD	t-value	p-value
Reading	Male	17.32	2.11	0.96	Not significant
	Female	17.65	2.08		
Writing	Male	16.88	2.25	1.12	Not significant
	Female	17.24	2.30		

No statistically significant gender-based differences were found in post-test reading or writing skills, suggesting that the AI applications were equally effective for both male and female students.

4.3 Qualitative Results (Student Reflections)

The qualitative responses affirmed the quantitative findings, illustrating increased student motivation, self-efficacy, and enjoyment in reading and writing tasks after using AI-powered learning tools and applications (app).

> *"I used to read with difficulty, but now the app reads to me and helps me understand. I can follow the story easily."* Grade 4 female student

> *"I'm writing words correctly now because the app corrects me every time I make a mistake."* Grade 5 male student

> *"The educational game made me enjoy writing. I didn't like it before."* Grade 3 female student

The students conveyed that AI tools offered immediate corrective feedback, which helped shape their literacy abilities by alleviating anxiety over errors and boosting confidence in their literacy skills. Multiple students indicated that AI systems eased tasks by adjusting the difficulty to their level of advancement, which they called "fair" and "encouraging." Some students noted that the gamified and interactive elements not only aided but also heightened the enjoyment in reading and writing, turning a once onerous task into a much-anticipated activity. Most notably, students prominently mentioned that these AI systems fostered a feeling of independence since they no longer needed constant teacher assistance to practice and sharpen their skills.

With regard to motivation, a majority of students considered AI lessons as "fun challenges" and were ready to attempt and finish more tasks than they usually did. Regarding self-confidence, the participants reported that watching their progress increase "showed that they could achieve" something after struggling. Students described the AI activities as "something to look forward to every day," which is the opposite of the feelings associated with dull traditional lessons, a description that was said repeatedly. Examining their responses as a group, AI lesson interventions appeared to have had an impact that went further than just improving technical literacy; these interventions helped change the students' mindset by fostering self-directedness, curiosity, and lowering the prospect and worry of failing, as well as enhancing active engagement.

5. Discussion

This research reports evidence that specific AI tools, particularly those that are adaptive, interactive, and simulation based, have a positive impact on the development of reading and writing skills for students with LD in Palestine. For every group under study, there was a marked increase in test scores following the programs, with the adaptive application group leading in both reading and writing. The control group that adhered to the traditional method of learning throughout the study period did not show any sign of improvement. No variations in outcomes across gender shows that the program benefited all participants equally. Comments from the participants support these claims and underline the increase in confidence, participation, and the simplicity of learning that the students experienced.

These observations correspond with the insights of prior research, underscoring the paradigm shift AI fosters in special education. For example, Evmenova et al. (2024) argued that generative AI provides superior writing feedback to that of special educators, which is equally proven with the writing improvements in the current study. Similarly, the findings of Goldman et al. (2024) were replicated multiple times in this study, concluding that AI-supported teaching enhances expressive fluency, spelling accuracy, and text organization among students with LD. The previously unconfirmed hypothesis of Yap et al. (2025) stated that adaptive applications, when combined with personalized AI-based tools in real time, excel at achieving phonemic awareness and reading fluency gains in a measurable manner.

This study presents an unmatched comparative study of three different learning methods: a hierarchy of effectiveness from simulation-based to interactive to adaptive. The findings coincide with those of Hopcan et al. (2023) and Voultsiou and Moussiades (2025), building on their ideas that adaptive learning systems, in theory, have the potential to be more pedagogically flexible and responsive than fixed instructional formats. Moreover, the qualitative evidence agrees with the findings of Marinelli et al. (2023), who concluded that serious games and interactive platform interventions were most effective in the development of literacy in language skills and students' motivation toward the learning process.

The results of this study reinforce the theoretical foundations guiding the research. According to cognitive learning theory, AI tools that offer real-time scaffolding, such as adaptive reading applications or grammar-correcting systems, enhance working memory and attention while reducing cognitive overload. The adaptive group's superior outcomes support this theory by demonstrating how AI can modulate task difficulty based on student performance. This aligns with Vygotsky's zone of proximal development (ZPD), which posits that students achieve the most progress when instructional support is provided just beyond their independent capability (Vygotsky, 1978). Adaptive AI applications appear to function as a dynamic "more capable peer," continuously adjusting task difficulty to remain within each student's ZPD.

The observed individualization of learning also supports differentiated instruction theory, as AI systems adapted content, pace, and feedback according to student needs. This confirms the rejection of hypotheses 1, 2, 5, and 6: significant differences exist in reading test scores between the experimental (AI) and control (traditional) groups; significant differences exist in writing test scores between the two groups; significant differences exist in reading outcomes based on the type of AI application used; and significant differences exist in writing outcomes based on the type of AI application used.

Hypotheses 3 and 4 are supported: no significant gender-based differences exist in reading skill improvement, and no significant gender-based differences exist in writing skill improvement. The equal impact across genders further reflects UNESCO's (2023) position that AI, when inclusively designed, can reduce disparities and enhance accessibility for marginalized students.

Additionally, the motivational effects, as indicated by student quotes such as "the game made me enjoy writing", are fully consistent with motivation theory. These findings support Cukurova et al. (2023) and Marinelli et al. (2023), who emphasized that enjoyment, autonomy, and self-efficacy make a successful AI-supported instruction. Reinforcement is noted in the self-determination framework (Ryan & Deci, 2000), in which intrinsic motivators such as autonomy, competence, and relatedness are examined. Students' remarks highlighting that AI tools offered them independence, reduced their anxiety, and enhanced their learning experience are consistent with SDT, which suggests that AI aids not only skill enhancement but also deeper motivational participation.

The research study as a whole is validated through these findings. The use of an AI-equipped adaptive reading application or a grammar correction tool that offers instant help, from the perspective of the well-established cognitive learning theory, improves the operation of working memory, maintains attention, and eases the mental load. The improved outcome of the adaptive group provides evidence for this framework, showcasing AI's ability to personalize the challenge of an activity promptly to the student's proficiency.

Table 6: Hypotheses evaluation summary

Hypothesis	Statistical Test	Result Summary	Decision
H1	t-tests (Table 2)	Significant difference in reading skills	Rejected
H2	t-tests (Table 3)	Significant difference in writing skills	Rejected
H3	t-test (Table 5)	No gender difference in reading improvement	Supported
H4	t-test (Table 5)	No gender difference in writing improvement	Supported
H5	ANOVA (Table 4)	Significant difference by AI application type (reading)	Rejected
H6	ANOVA (Table 4)	Significant difference by AI application type (writing)	Rejected

The qualitative data explained students' emotional as well as cognitive engagement. Students expressed that AI tools provided them with freedom to accept errors, made stories easier to follow, and the whole learning process fun. This confirms findings by Kambouri et al. (2023) and Filiz et al. (2025), on speech-to-text and NLP-based platform for student autonomy and the reduction in student performance anxiety, respectively. These data strengthen the notion that AI tools nurture emotionally safe and sound pedagogically viable learning environments, a dimension that proves most necessary, especially for LD students.

The Palestinian private school implementation of the study on AI-learning systems provides insight into avenues that bring together challenges and opportunities. The improvements indicate the tremendous potential that AI still has, especially in environments with limited infrastructure. However, teachers' lack of preparation regarding the system, limited availability of Arabic-language AI platforms, and some infrastructure gaps have been cited as major constraints by Qaddumi et al. (2023) and Ding et al. (2024).

Incompatible with what Yan and Liu (2025) cautioned, ethical considerations when AI is deployed must uphold student autonomy, data privacy, and instructional equity, all worthy of thoughtful planning in the future. It is also important to interpret these results within the broader Palestinian context, where ongoing conflict, instability, and resource scarcity create systemic challenges for schools. Such conditions may limit the scalability of AI interventions and affect the generalizability of findings, even as they highlight the urgent need for innovative solutions to support students with LD in under-resourced environments.

This study contributes to theoretical integration by testing the cognitive learning theory, differentiated instruction, and motivation theory in an AI-mediated special education environments. The study advocates that more priority be given to adaptive AI tools due to their proven pedagogical merits. Lack of disparity by gender further indicates that AI can be an inclusive tool, supporting UNESCO's (2023) policy on inclusive education. It further includes a framework to integrate AI into literacy instruction with aspects of structured teacher training, culturally relevant design of AI, and continuing institutional support, corresponding with the findings of Salas-Pilco et al. (2022) and Fu and Weng (2024) about responsible AI integration.

However, the study acknowledges limitations such as a concentration on private schools and a short intervention period. Hence, there is an urgent need for future studies to explore long-term outcomes, scalability for public schools, and AI efficacy in other LDs, such as dyscalculia, ADHD, etc., as suggested by Delagrammatika et al. (2024). Furthermore, with a larger AI integration with other emerging technologies such as emotion recognition, virtual reality, internet-enabled learning, there may exist a possibility for deeper personalization and accessibility, as suggested by Li and Wilson (2025).

6. Conclusion

This study investigated the impact of AI applications, specifically adaptive, interactive, and simulation-based tools, on enhancing reading and writing skills among students with LD in Palestinian schools. The findings confirmed statistically significant improvements in literacy outcomes for all experimental groups, with adaptive applications yielding the most substantial gains. In contrast, the control group, which received traditional instruction, demonstrated no significant progress. These results underscore the transformative potential of AI technologies in special education, particularly when aligned with individualized, adaptive learning frameworks.

Importantly, the absence of gender-based differences suggests that AI applications offer equitable benefits to both male and female students, thereby supporting inclusive pedagogical goals. Additionally, qualitative feedback from students affirmed increased motivation, confidence, and engagement in learning tasks, reflecting the psychosocial value of AI-enhanced instruction alongside its cognitive benefits. The study contributes theoretically by integrating cognitive learning theory, differentiated instruction, and motivation theory to explain the mechanisms through which AI supports skill acquisition among students with LD. Empirically, it offers a comparative evaluation of AI tool types, highlighting the superior impact of adaptive systems, an insight of practical relevance to educators, curriculum designers, and educational policymakers.

Theoretically, this study contributes to Arabic-language educational literature by proposing a structured framework for integrating AI applications into special education, with a specific emphasis on literacy development. It represents one of the first empirical investigations of its kind in the Palestinian educational context, addressing a significant gap in research. At the same time, the findings should be viewed within the realities of Palestinian schools, where conflict-related disruptions and systemic constraints shape both the challenges and the urgency of implementing innovative educational technologies.

On a practical level, the findings provide actionable insights for multiple stakeholders. Teachers can use these results to select more effective AI tools tailored to student needs. Curriculum developers are encouraged to design literacy interventions that incorporate AI support, especially tools that are adaptive and linguistically relevant. Policymakers can use the study's implications to inform educational technology strategies and to prioritize infrastructure development that ensures equitable access to AI-based learning. Parents are empowered to support their children's literacy development by identifying culturally appropriate, educational applications for home use. Meanwhile, AI developers are encouraged to prioritize features that ensure adaptability, accessibility, and Arabic-language content in their educational tools.

Several limitations should be acknowledged. Methodologically, the reliability of findings is inherently tied to the validity and reliability of the measurement instruments employed in the study. Technologically, the successful application of AI tools depends on the availability of appropriate digital infrastructure and

device access in schools. From a human implementation standpoint, the consistency of intervention was contingent upon teacher cooperation and regular student attendance throughout the experimental period. Statistically, the robustness of the findings is influenced by the choice and suitability of analytical techniques used to measure the outcomes. Additionally, the generalizability of the results is limited by the sample, which was confined to private schools in Jerusalem and may not fully represent broader national or regional educational contexts.

7. Recommendations

Based on the findings, several key recommendations emerged. First, adaptive AI applications should be prioritized in educational programming due to their superior effectiveness in improving reading and writing outcomes. Second, professional development initiatives should be expanded to ensure that teachers are adequately trained in the pedagogical and technical aspects of AI integration.

Third, investment in educational infrastructure is essential to enable widespread and equitable adoption of AI tools, particularly in underserved and special education settings. Fourth, developers should focus on creating culturally contextualized, Arabic-language AI tools that address the specific cognitive and linguistic needs of students with LD. Lastly, future research should explore the long-term effects of AI-based interventions through longitudinal designs and should include the development of robust assessment tools to evaluate sustained literacy gains.

This study reinforces the critical role of AI applications in addressing persistent literacy challenges among students with LD. Through the thoughtful integration of adaptive technologies, culturally responsive content, and systemic capacity-building efforts, education systems in Palestine and similar contexts can move closer to realizing inclusive, equitable, and effective learning environments for all students.

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