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IMPROVING MEMORY IN BOYS WITH MILD INTELLECTUAL DISABILITY THROUGH ARTIFICIAL INTELLIGENCE-BASED MOBILE APPS: A SINGLE-SUBJECT STUDY

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ABSTRACT
Children with mild intellectual disability (MID) tend to experience memory problems, which impede learning in school and their daily functioning. Although AI-based adaptive instructional tools have become a reality, there is little evidence regarding their effects on memory performance among children with MID. This paper assessed the effectiveness of AI-driven mobile apps in improving memory function among boys with MID at a government special education school in Punjab, Pakistan. A single-subject experimental design, a repeated-measures experiment. Six children aged between 7-14 years were put in a 12-week individualized intervention involving the use of AI-based apps, Khan Academy Kids, and JADE Autism. The researchers developed a checklist, an observational tool containing 25 items, to assess memory performance before, during, and after the interventions. The data were compared using the effect-size statistic Tau-U, which is appropriate for the single-case design. The changes in memory were substantial and statistically significant, indicating improvement over the course of the intervention. The comparisons of pre-intervention phases revealed homogeneous high Tau-U (Tau-U = 1.00, $p < .001$), which shows instant and strong effects. Satisfactory retention was observed in the pre-intervention and post-intervention comparison (Tau-U range = 0.71-0.95, $p < .001$). Contrary to the fact that the withdrawal of AI support led to the significant decrease (Tau-U range = -0.79-0.97, $p < .001$), the performance after the intervention was more positive than that at the baseline, which means that memory gains were partially maintained. Mobile applications based on AI were found to be effective in enhancing the memory of boys with MID. The reduction after withdrawal supports the significance of the maintenance and gradual fading strategies to support the functioning of the long-term memory in the special education conditions.
Keyword: Mild Intellectual Disability, Artificial Intelligence, Memory Enhancement, Single-Subject Design, Mobile Learning Apps, Special Education.

INTRODUCTION

Schools readily recognize the importance of accommodating the needs of students with sensory or physical disabilities. Still, these institutions have little understanding of how to meet the needs of boys with mild intellectual disabilities (Angelka et al., 2018). As a result, they are given little attention. Boys with MID commonly experience difficulties in core cognitive processes such as attention, working memory, and problem-solving, which make it harder for them to process, store, and retrieve new information and to remember things (Hronis et al., 2017; Schalock et al., 2021). Their poor memory affects their academic progress and daily life.

Memory is one of the most vital cognitive functions, affecting almost all aspects of human life. The core of our entire mental process is a strong and active memory, which guarantees us survival, learning, and success. It is even the case with self-identity, which is determined by our memories (Drigas, et al., 2022). One of the most complex challenges encountered by child with MID is memory problems. They lose newly acquired information, have troubles remembering instructions, and necessarily need to be reminded of simple tasks quite often (Van der Molen et al., 2009). The impairment of memory in many children in school age leads to impairment of reading comprehension, memory and task performance (Drigas et al., 2022). Due to these limitations, these children need a support system that can help them improve their memory. Modern technology, especially artificial intelligence, can be helpful and supportive in this regard (Faiz & Hina, 2024).

Techniques such as Artificial Intelligence (AI) have recently become revolutionary tools in numerous fields and have actually changed a lot in the way that the human brain can be improved through ways such as memory and problem-solving. This transformation is mainly a result of the progressive development of machine learning and deep learning algorithms and natural language processing tools. These new technologies unlock a new level of human cognitive enhancement and transform the ways in which people and information interact in their active lives. It is most possible to speak about AI's positive impact on cognitive functions in regard to memory and problem-solving. Machine intelligence applications have become more or less indispensable in everyday applications, offering service outputs that go beyond mere cognition. For example, SNote and C Active, a digital note-taking smart app that implemented advanced AI algorithms, has complicated abilities to set note reminders, use predictive text, and organize text data. These memory aids assist the targeted users to handle a lot of information more effectively, hence assisting users to easily retrieve and apply information when the need arises. An implementation of AI is used to remind the users on time and use data processing to alert the user and give suggestions, this way a lot of cognitive loads is eased, thus improving productivity (Haider, et al., 2024: Khalid, et al., 2024).

Although the artificial intelligence (AI) in education rapidly expands, there is still no detailed and specific research conducted on the effects of AI on memory. The majority of earlier studies have generalized learning outcomes (e.g. academic achievement or performance), thus complicating the determination of the precise impact of learning outcomes on memory. In some studies, only immediate post-tests have been conducted thus it has been hard to tell whether the knowledge learnt is short-term or long-lasting. Thus, this gap demonstrates that research is necessary to explore how a memory of boys with intellectual disabilities can be enhanced by introducing AI-based applications. The research aims to discuss the enduring memory impairment of boys with mild intellectual disabilities, which hinders their academic achievement in special education. AI-based mobile applications were selected because they are structured, adaptive, and repetitive, consistent with the principles of cognitive learning. Individual change over time was recorded, and the functional effect of the AI-based memory intervention was assessed using a single-subject design.

Statement of the Problem

Boys with mild intellectual disabilities usually struggle with the ability to remember the information and revisit what they have recently read or watched. This influences their studies in school and life. Even the conventional teaching techniques do not offer individual attention to enhance the memory of such children. Artificial Intelligence (AI) apps have the potential to improve these children's memory. Therefore, this research has focused on the implementation of AI applications to improve these children's memory.

SIGNIFICANCE OF THE STUDY

This research will focus on improving the memory of boys with mild intellectual disability using artificial intelligence (AI) applications. They often experience persistent memory difficulties that affect their learning, classroom participation, and daily functioning, necessitating targeted instructional support. AI-based applications will provide structured practice, adaptive feedback, and repetition that will improve memory development in educational settings. The results of the present research will assist special education educators to select and apply the right technological tools in order to overcome memory-related problems. The research will further provide some practical implications on how AI-based technology-assisted learning strategies can be implemented in the special education classes.

Research Objectives

The study aims to:

1. examine the effectiveness of AI-based mobile apps in improving memory among boys with mild intellectual disabilities.
2. implement AI-based mobile apps as part of classroom instruction to support memory development in boys with mild intellectual disabilities.
3. compare changes in memory across different intervention phases following the use of AI-based mobile apps.

Research Questions

The research is based on three questions:

1. To what extent do AI-based mobile applications support memory development in boys with mild intellectual disabilities?
2. How does classroom use of AI-based mobile applications influence memory performance in boys with mild intellectual disabilities?
3. Are there measurable differences in memory outcomes across intervention phases when AI-based mobile applications are used?

LITERATURE REVIEW

Mild intellectual disability means that a person's thinking and adaptive skills are below average, usually two to three standard deviations below the normal range. In simple terms, the condition means their ability to learn is slow, and they typically reach the academic level of a fourth- or fifth-grader, even with support. About 85% of all people with intellectual disabilities fall into this mild category (Patel, 2020). According to Lindblad (2017) & Fernell (2025), the causes of mild intellectual disability often occur before or around birth, but the exact cause is usually unknown. Still, these children need ongoing support in school and daily activities. Nouwens et al., (2017) found that individuals with mild intellectual disabilities have different strengths and needs, so education and support should be personalized. Due to their reduced memory capacity, these children struggle to recall what they have learned. They forget quickly.

Memory

Memory is a core cognitive ability that enables children to receive, retain, and recall information to be used in the future. It facilitates almost all functional areas of learning: reading, problem-solving, language development, and social interaction. Memory enables children to relate new information to what they already know to make sense of the surrounding world and to use acquired knowledge in other scenarios (Sun & Kang, 2022). Gathercole and Alloway (2008) suggest that memory is essential for academic success, particularly in education, because it helps children follow instructions, solve problems, and process information as it comes in. Well-endowed children in memory have increased learning powers, are more likely to remember longer, and perform well in academic and day-to-day life.

Memory Problems in Mild Intellectual Disabilities

Children with MID also experience memory difficulties in learning and recalling new information. They experience problems with storing, arranging and recollecting what they have learned especially when they are supposed to work on concepts that are abstract or have to learn in sequences. There is a tendency towards short-term memory and working memory deficits in such children, making it more challenging to adhere to instructions, solve problems, and relate new learning to prior knowledge (Van der Molen et al., 2010).

Artificial Intelligence

Artificial intelligence has tremendous potential to enhance cognitive skills by developing adaptive learning experiences (Faiz & Hina, 2024). Memory is needed to learn, understand, and apply information to life by the child. The AI learning tools support the memory by practicing it frequently and provide prompts and feedback based on the requirements of a child. Some of the helpful features of these AI applications include spaced repetition, whereby it takes the element of repetition to children on the same topic at different times so that they can be in a position of memorizing.

Memorization found that memory development is witnessed more among the children who use AI-enhanced reading and math programs due to these repetitive and individual activities (Nasir et al., 2025). With these systems the learning of a child is observed, and sets of reviews are given to him or her based on what he or she forgets or is failing. This assists in the enhancement of the learning process and in focusing the learning process. But important are the uses of the tools that kids employ. There is a higher level of retention when children do something meaningful with what they are being taught. Correction and repetition when there is the right timing are much better than learning enhanced by curiosity and active seeking (Al Saeed, 2021). So, the goal to accomplish by using AI is to make kids think, exercise, and rethink in the same manner as when a good teacher leads children through the process.

Artificial Intelligence-based Mobile Apps

Mobile app is the type of software that is designed to be executed on a phone, tablet, or touchscreen (Chung et al., 2024). The popularity of these apps lies in the fact that the apps are convenient to use and there is an immediate access to various services. They can be of any type: games, calculators, web browsers and educational tools. Majority of the apps are small and specific, which makes them suitable in everyday life. On top of simple use, interactive and personalized learning experiences can also be provided by them, particularly useful in special education. These educational applications can be used by teachers to interact with students and enhance their recognition skills (Beili et al., 2024).

Role of AI Apps in Improving Memory

AI apps play an essential role in improving cognitive capacity in children with intellectual disabilities. Lumosity and Cognition applications are used to train the memory because they focus on the major cognitive functions, which include attention, logical thinking, and memory abilities. One can develop early learning skills with the assistance of the Khan Academy Kids (interactive games to practice attention and recognition) and the games (Osmo and Toca Boka) to practice creativity and problem-solving. Individualized instruction, such as DreamBox Learning and Duolingo, is an adaptive learning platform that enhances memory and language acquisition. Similarly, Bee-Bot can also support sequencing and logical thinking through play. The technologies can be integrated to allow teachers and parents to design interactive, dynamic, and meaningful learning activities to promote the cognitive development of the children in general. (Faiz & Hina, 2024).

Previous Researches

Despite the speed of AI development in the sphere of education and the existence of several general syntheses of effectiveness conducted, the precise description of memory outcomes has not been elaborated so far. Previously conducted reviews have hampered evidence synthesis because they usually combine heterogeneous measures based on broad labels,

like achievement or learning, or the focus is on the usability and engagement, but not on cognitive outcomes, per se (Shanmugasundaram and Tamilarasu, 2023). The only outcome that is frequently presented is immediate post-instruction tests, and it is hard to differentiate the short-term performance and long-term retention. In addition, the effects are not often categorized by the process of memory that is targeted (based on the studies). Gains can be indicative of more efficient encoding, superior scheduled recall, less extraneous load that liberates working memory or a combination of both, but most syntheses fail to project results onto those constructs. Chatbots and LLM review supports highlight promise of study support, though with short follow-up intervals and variable assessment formats, which constrain the ability to make inferences regarding delayed retention. Intelligent tutoring and augmented reality meta-analyses show that there is a statistically significant mean improvement in learning, but few distinguish immediate and delay of recall and retention, or even which design features best support memory operations at different levels (Akchayir and Akchayir, 2017; Garzon and Acevedo, 2019; Wollny et al., 2021).
The existing literature shows that boys with mild intellectual disability (MID) have long-standing problems with their memory mechanisms that have a negative impact on their academic learning and daily functioning (Hronis et al., 2017). The traditional methods of instruction in special education are not student-centered but universal and do not meet the needs of each student; therefore, they do not suit well in the process of promoting the memory of individuals (Angelka et al., 2018). Recent findings indicate that applications could be applied to facilitate cognitive and memory development, with the help of technologies and artificial intelligence, in the forms of adaptive practice, immediate feedback, and repetition (Almufareh et al., 2023; Sarcco et al., 2023). Despite the positive results noted, the majority of studies concentrate on the short-term achievements in terms of knowledge when an app is used, and very little is known about the ability to retain and maintain memory skills after the technological help is removed (Risko & Gilbert, 2016). Thus, there is still a gap in the research on the AI-based memory intervention phases and their maintenance among MID boys in special education schools.

METHODOLOGY

The study employed a single-subject experimental design with repeated measurements across pre, during and post-intervention phases to examine the effects of AI-based mobile apps (Khan Academy Kids & JADE Autism) on memory in boys with mild intellectual disabilities (Cranmer, 2017; Jimenez, 2018). Under this design, the performance of every participant was to be measured at three stages, all of which were before the intervention, during the intervention, and after the intervention (Fabrizi & Winston, 2016). Every child was his control and, thus, there was no need to compare a child with another, only to observe the individual progress. This methodology was considered suitable due to the low sample and the necessity to deliver intervention individually, which is the subject of the personalized research of special education (Alqraini, 2017).

Population and Sample

The sample population was the boys with the mild intellectual disabilities, who were studying in the government special education schools at Punjab, Pakistan. All six students between the age of 7-14 years were sampled in Government Special Education Centre for 03-Remaining Disabilities, Okara on basis of specific inclusion criteria. Inclusion criteria are predefined characteristics used to identify participants who are included in a study. They help ensure the study's validity and focus by defining who qualifies to participate (Patino & Ferreira, 2018). These were the following criteria; (a) possessed an official disability certificate that demonstrated mild intellectual disability, (b) possessed reports given by teachers that he experienced difficulties in attention and (c) parental consent, written. The study included only boys; girls were excluded because the selected special education school was gender-segregated. The researchers have examined several articles on the uses of artificial intelligence and have chosen to use mobile applications in the study. The selection of the apps was determined by their AI features like personalization, adaptive content, and feedback. The applications were user-friendly to educators and learners and helped to improve the memory abilities.

Procedure for Implementing the Intervention Plan

The intervention lasted for 12 weeks and comprised 25 structured classes. The sessions lasted about 10 minutes each, with a 5-minute break to ensure students were not fatigued and their focus was not lost. They were held individually, which gave each member a face-to-face approach. The major teaching materials were AI-based apps (Khan Academy Kids & JADE Autism) since they were selected due to the ability to deliver adaptive, interactive, and engaging activities to foster memory and achieve the learning goals of a boys with MID. All activities were supported by lesson plans designed in accordance with the curriculum guidelines provided by the Punjab Department of Special Education.

Research Instrument for Data Collection

In this study, the researchers developed a checklist to evaluate the performance of students. The checklist was divided into 25 observable tasks to assess the improvements of memory. Each of the items was rated using a 5-point Likert scale, with excellent being the top rating and very poor being the lowest one. The checklist was applied three times: at baseline (pre-intervention), during the intervention, and post-intervention to identify changes over time. Sample questions on the checklist were as follows: (a) the possibility to recollect the sequence of images after a short delay,

(b) the ability to match the pictures already introduced with the appropriate words, and (c) to repeat simple directions in the correct order. The checklist was developed based on the relevant literature and revised by special education specialists to ensure content validity. Reliability was supported through consistent administration and repeated measurements across all intervention phases. Such a repeated-measures design gave a chance to observe and compare the alterations of memory throughout the periods of the intervention. The researchers were loyal to the implementation, following the structure of the session and constant deployment of AI-based applications and equal exposure to all participants.

Data Analysis & Interpretation

The quantitative data were analyzed using Tau-U, a nonparametric effect-size statistic commonly used in single-subject research. The performance scores for memory were collected at three intervention points: pre-test, during-intervention, and post-test. They were tabulated to analyze changes in the phases. Tau-U was chosen due to failure to meet the normality requirements and frequent observations of a limited number of subjects. The technique is best suited for determining phase-to-phase improvements and for considering possible baseline trends. For each comparison (pre vs. during, pre vs. post, and during vs. post), Tau-U values, corresponding z-scores, and p-values were calculated. Tau-U values were computed using a single-case data analysis tool designed for non-overlap statistics. Baseline data were visually inspected for stability, and where baseline trends were present, trend-corrected Tau-U was applied. The analysis assumed independent observations and ordinal-level measurement. These indicators were used to determine the magnitude and direction of change across phases. Positive Tau-U values reflected improvements in memory performance, whereas negative values suggested a decline. The p-value for each change was used to determine its statistical significance. The review of descriptive task scores and performance trends was compared with the Tau-U results to provide a more concise view of individual progress. The specific student trends were analyzed to determine the time point of the most significant gains and their persistence after the intervention. Ages were summarized as demographic variables to provide context for the analysis.

Ethical Considerations

Ethical approval was obtained from the relevant institutional authority, and permission was granted by the administration of the selected government special education school. Written informed consent was obtained from parents and legal guardians of all participants, and confidentiality was maintained throughout the study.

Demographic Distribution

Table 1 Age-wise classification of respondents

Age	Frequency	Percent
7 to 8	1	16.7%
9 to 10	1	16.7%
11 to 12	2	33.3%
13 to 14	2	33.3%
Total	06	100%

Table 1 presents the age-wise distribution of six participants: one each (16.7%) was in the 7-8 and 9-10 age groups, and two each (33.3%) were in the 11-12 and 13-14 age groups. This suggests that most participants were between 11 and 14 years old.

Figure 1 *Line graph 1 shows participant 1's performance on 25 tasks in three stages.*

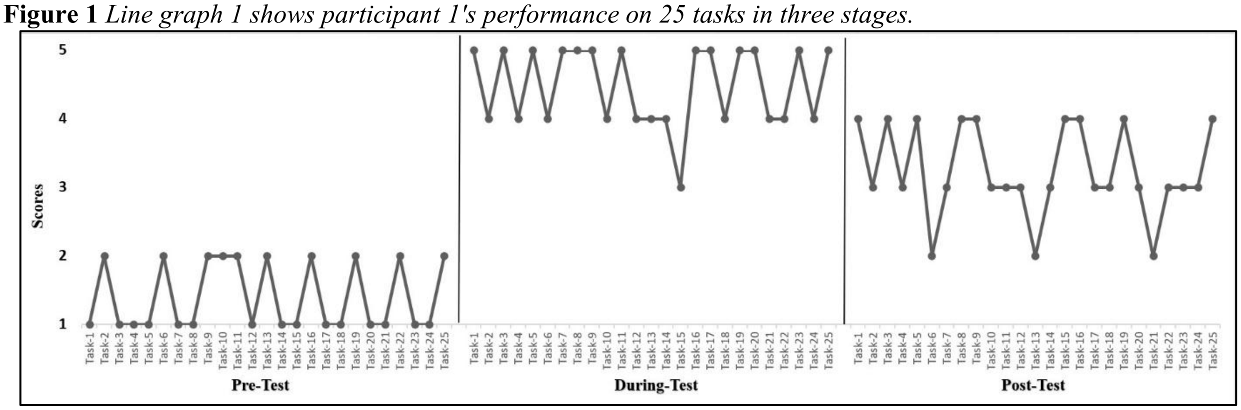

Figure 1 presents the result of participant 1 in 25 memory tasks during the pre-test, the intervention time and post-test. The baseline scores were poor and the scores were between 1-2 and majority of the values were low in performance in memory. The introduction of AI-based activities showed an immediate and noticeable improvement during the intervention stage, with scores increasing and remaining primarily at levels 4 and 5. During the post-test phase, performance decreased slightly and became more erratic, with scores typically falling between 3 and 4, though they remained well above the baseline. This decline may be attributed to the withdrawal of structured AI supports, such as immediate feedback, guided prompts, and repeated practice, as well as the absence of a maintenance phase, which may have limited consolidation and independent recall once active intervention ended.

Figure 2 *Line graph 2 shows participant 2's performance on 25 tasks in three stages.*

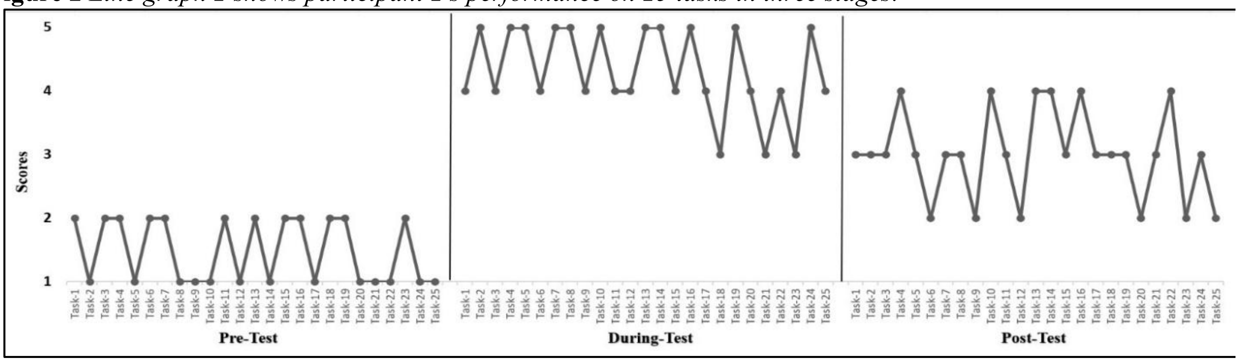

Figure 2 illustrates the results for participant 2 across 25 memory tasks assessed during the pre-test, intervention, and post-test phases. Pre-test performance was low, with scores mostly at levels 1 and 2, indicating poor baseline memory functioning. The introduction of AI-based activities resulted in significant improvements in performance during the intervention stage, with scores typically increasing to levels 4 and 5 across most activities. Once the intervention was withdrawn, post-test performance showed a slight decline and greater variability, with scores between levels 2 and 4; however, the scores were higher than baseline levels. This decrease may indicate the loss of continuous AI, including immediate feedback and guided practice, and the absence of a defined maintenance stage, which may have limited the ability of memory gains to remain stable after active support was withdrawn.

Figure 3 *Line graph 3 shows participant 3's performance on 25 tasks in three stages.*

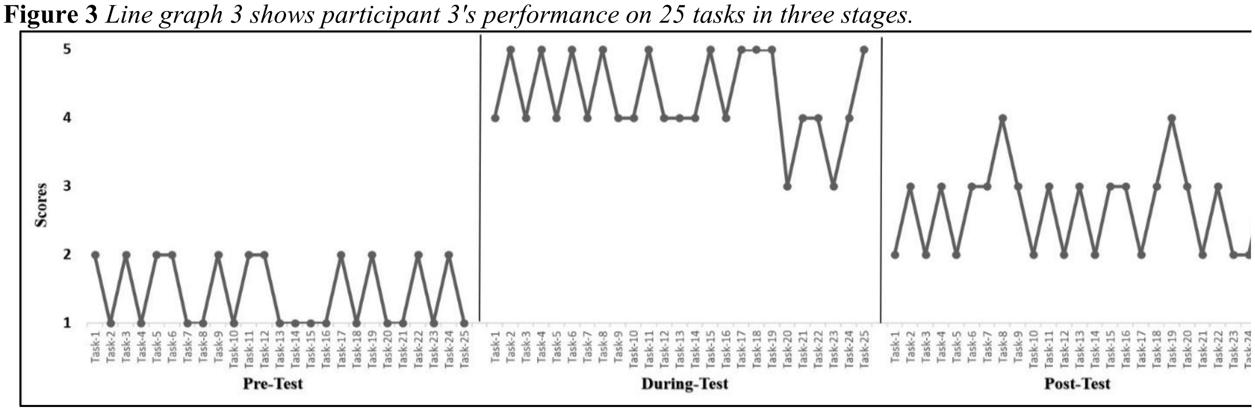

Figure 3 presents participant 3's scores across 25 memory tasks during the pre-test, intervention, and post-test phases. In the pretest, performance was low, with scores mostly at levels 1 and 2, indicating a low baseline level of memory ability. Following the introduction of AI-based activities, a marked improvement was observed during the intervention period, with task scores higher and often maintained at levels 4 and 5, suggesting that memory performance improved with guided practice. During the post-test, scores exhibited greater variability and a decline in overall level, with most scores between 2 and 4 (higher than during the pre-tests). Such a decrease could be attributed to the fact that no active AI guidance and practice opportunities remained, and no designated maintenance phase that would restrict the long-term consolidation and independent recall after the intervention.

Figure 4 *Line graph 4 shows participant 4's performance on 25 tasks in three stages.*

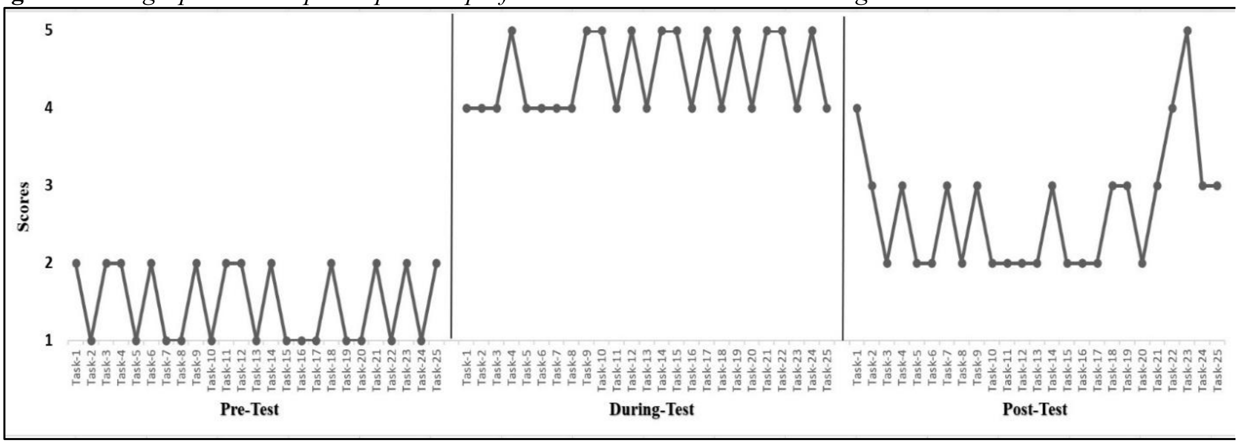

Figure 4 shows the scores of participant 4 in 25 memory tasks that were evaluating the participant in the pre-test, intervention and post-test. In the pre-test stage, the performance was low, and the scores were mostly varying between 1 and 2, which depicts that the initial level of functioning of the memory was low. As the AI-based intervention began, the improvement in scores became apparent, as the scores grew, and were often kept on a higher level, primarily between 4 and 5, which represent the improved performance in the task provided by the supported conditions. After the intervention was withdrawn, the post-test scores began to decrease and became more varied with the performance usually being between 2 and 3, but there were also instances where higher scores would be seen. In spite of this loss, the performance after test was higher than the baseline. This post intervention decline might be associated with the elimination of ongoing AI instruction and reinforcement, and lack of organized maintenance period, which might have limited memory gains stabilization and retention in the absence of AI help.

Figure 5 *Line graph 5 shows participant 5's performance on 25 tasks in three stages.*

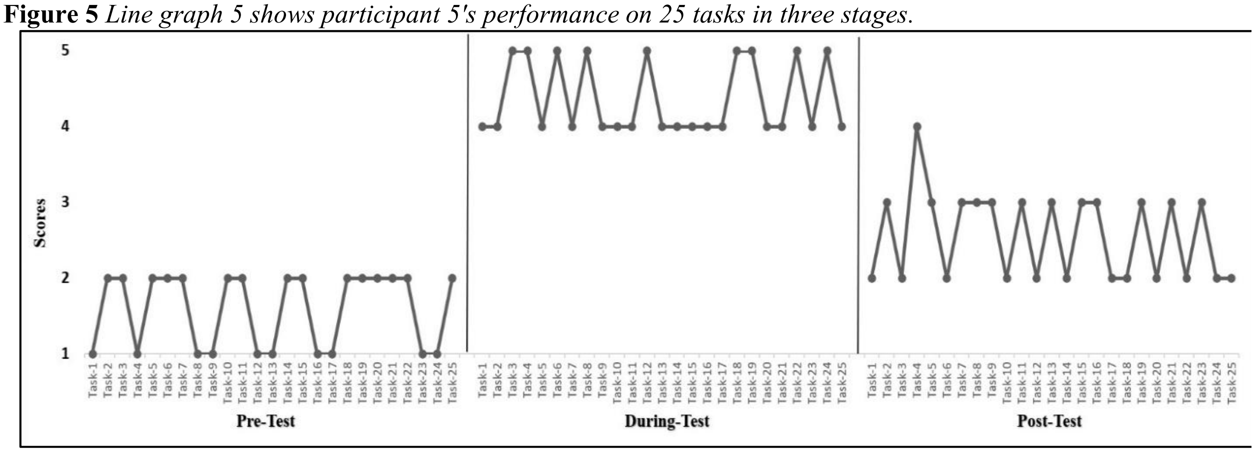

Figure 5 depicts the performance of participant 5 on 25 memory tasks in the pre-test, intervention, and post-test periods. The responses were generally low, fluctuating during the pre-test stage, typically between 1 and 2, and there was little base memory performance. After the implementation of the AI-based intervention, the task performance was significantly better, and the scores increased and usually stayed on a higher level, usually 4 and 5, which demonstrates that there is an improvement in memory functioning in the framework of the guided practice process. Post-test scores decreased and became more variable; they tended to be between 2 and 3, but were still higher than at the beginning of the intervention. This reduction may be associated with the removal of structured AI support, including immediate feedback and repeated practice, as well as the absence of a maintenance phase, which may have limited the consolidation and independent retention of learned memory.

Figure 6 *Line graph 6 shows participant 6's performance on 25 tasks in three stages.*

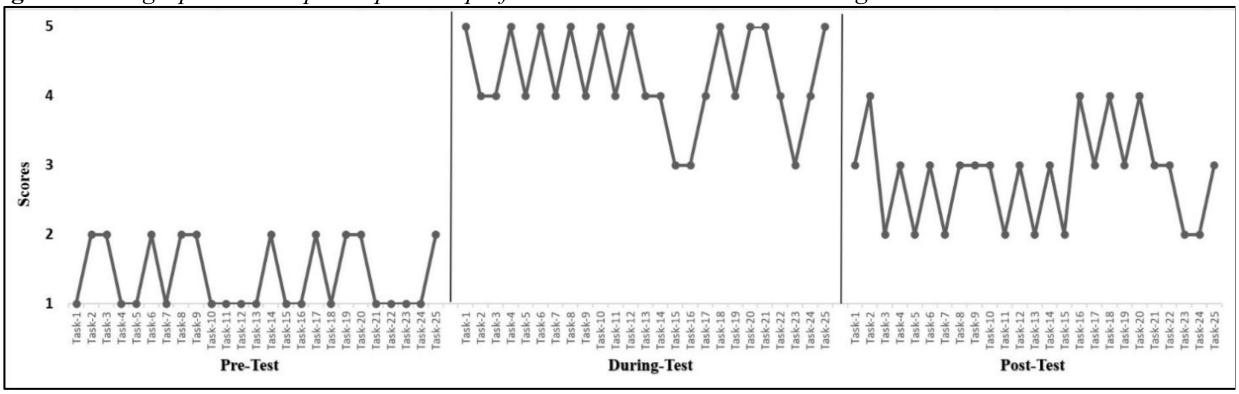

Figure 6 presents the performance of participant 6 through 25 on memory tasks during the pre-test, intervention, and post-test. The pre-test scores were not high with 1 and 2 taking the majority percentage of the scores showing that there was a poor performance in terms of baseline memory. After the intervention was implemented using the AI, task scores were significantly improved and could be frequently kept at a better level between 4 and 5, which means that the structured environment allowed improvement of memory performance. It was found that after the intervention was withdrawn, post-test scores decreased significantly and showed greater variability, with scores primarily between 2 and 4, yet still higher than pre-test scores. This drop may be linked to the abolition of persistent AI scaffolding, such as hints and instant feedback, and the absence of a sustaining stage, which might have limited the consolidation of memory gains and autonomous remembrance after the intervention.

Table 2 *Tau-U effect sizes for participant 1's memory task performance across the intervention stages.*

Phase contrast	Pairs	Tau-U	Z	p	90% CI
Pre vs During	625	1.000	6.0634	< .001	0.729 - 1.00
Pre vs Post	625	0.952	5.7723	< .001	0.681 - 1.00
During vs Post	625	-0.792	-4.8022	< .001	-1.00 - 0.521

Table 2 presents the Tau-U effect sizes for participant 1 across 25 memory tasks at the pre-test, intervention, and post-test stages. The pre-test-to-in-intervention improvement was substantial and statistically significant (Tau-U = 1.00, p < .001), indicating a reproducible and immediate response to the AI-based memory activities. The comparison of pre-test and post-test also reported a large and significant effect (Tau-U = 0.952, p = .001), indicating that a substantial amount of the gains was retained after the intervention. There was, however, a significant decrease from intervention to post-test (Tau-U = -0.792, p < 0.001). This was probably brought about by the elimination of AI prompts, feedback, and guided practice, which suggests performance improvement by active cognitive scaffolding was improved by the intervention. The post-test performance was significantly higher than the baseline, even though the importance of the improvement is diminished compared to the first one, which points to the presence of a lasting effect on memory.

Table 3 *Tau-U effect sizes for participant 2's memory task performance across the intervention stages.*

Phase contrast	Pairs	Tau-U	Z	p	90% CI
Pre vs During	625	1.000	6.0634	< .001	0.729-1.000
Pre vs Post	625	0.7072	4.288	< .001	0.436-0.979
During vs Post	625	-0.8112	-4.9186	< .001	-1.000-0.540

Table 3 presents the Tau-U values for participant 2 during the pre-intervention, intervention, and post-intervention phases. The pre-test-to-during-intervention (Tau-U = 1.00, Z = 6.06, p = .001) showed a statistically significant improvement, indicating a strong short-term effect of AI-based memory activities. The comparison between the pre-test and the post test also reported a significant positive effect (Tau-U = 0.707, Z = 4.29, p <.001) meaning that a large section of the gains was maintained post-intervention. However, a significant reduction was found between the during-intervention and the post-test (Tau-U = -0.811, Z = -4.92, p =.001) and which implies that post-test there was a lesser performance by the active AI support was discontinued. Despite this decrease, post-test performance remained clearly above baseline levels, confirming a sustained improvement in memory skills.

Table 4 *Tau-U effect sizes for participant 3's memory task performance across the intervention stages.*

Phase contrast	Pairs	Tau-U	Z	p	90% CI
Pre vs During	625	1.000	6.0634	< .001	0.729-1.000
Pre vs Post	625	0.72	4.3656	< .001	0.449-0.991
During vs Post	625	-0.8800	-5.3358	< .001	-1.000-0.609

Table 4 presents the Tau-U results for participant 3 across the pre-intervention, intervention, and follow-up periods. A comparison of the baseline and intervention revealed a maximal and statistically significant improvement (Tau-U = 1.00, Z = 6.06, p = .001), indicating a clear and stable improvement as soon as the AI-based memory activities were introduced. It was also a significant improvement, as baseline performance was compared with post-test results (Tau-U = 0.72, Z = 4.37, p < .001), indicating that most of the gains were retained even after the end of the intervention. Conversely, performance decreased considerably when the intervention was withdrawn (Tau-U = [?]0.88, Z = -5.33, p < .001), with lower scores observed after the removal of the structured AI support. However, the meaningfully increased performance after the test, compared with the baseline, demonstrates the sustained positive impact of the AI-sustained memory tasks on this participant.

Table 5 *Tau-U effect sizes for participant 4's memory task performance across the intervention stages.*

Phase contrast	Pairs	Tau-U	Z	p	90% CI
Pre vs During	625	1.000	6.0634	< .001	0.729-1.000
Pre vs Post	625	0.7696	4.6664	< .001	0.498-1.000
During vs Post	625	-0.8928	-5.4134	< .001	-1.000--0.621

Table 5 reports the Tau-U results for participant 4 across the pre-test, during-intervention, and post-test phases. The comparison between pre-test and during-intervention shows a very strong and statistically significant improvement (Tau-U = 1.00, Z = 6.06, p < .001), indicating a rapid rise in memory performance after the AI-based activities were introduced. A significant improvement was also observed from pre-test to post-test (Tau-U = 0.7696, Z = 4.67, p < .001), suggesting that much of the improvement was still present after the intervention concluded. In contrast, performance declined significantly from during-intervention to post-test (Tau-U = −0.8928, Z = −5.41, p < .001), showing that the highest scores occurred during active AI use. This reduction is most probably because of the elimination of supervised help and direct feedback. Nevertheless, the post-test scores were still significantly higher than the baseline levels and this showed a long-lasting positive impact on memory performance.

Table 6 *Tau-U effect sizes for participant 5's memory task performance across the intervention stages.*

Phase contrast	Pairs	Tau-U	Z	p	90% CI
Pre vs During	625	1.000	6.0634	< .001	0.729-1.000
Pre vs Post	625	0.712	4.3171	< .001	0.441-0.983
During vs Post	625	-0.9744	-5.9082	< .001	-1.000--0.703

Table 6 indicates the results of the Tau-U of participant 5 at pre-intervention, during-intervention, and post-intervention stages. The statistical significance of the difference between the pre-test and the intervention period was high (Tau-U = 1.00, Z = 6.06, p <. 001) and this shows a steady and immediate reaction in case of the introduction of AI-based memory tasks. The pre-test/ post-test analysis also suggested the presence of significant positive effect (Tau-U = 0.712, z = 4.32, p = 0.001), meaning that a considerable percentage of the gains had been maintained after the intervention. Nonetheless, the decrease was significant between the during-intervention and post-test periods (Tau-U = -0.974, Z = -5.91, p < .001), indicating that participants performed best during active use of AI. This decrease is likely due to the termination of the AI supports that had been organized, rather than to the loss of learning, since post-test performance was clearly above baseline.

Table 7 *Tau-U effect sizes for participant 6's memory task performance across the intervention stages.*

Phase contrast	Pairs	Tau-U	Z	p	90% CI
Pre vs During	625	1.000	6.0634	< .001	0.729-1.000
Pre vs Post	625	0.832	5.0447	< .001	0.561-1.000
During vs Post	625	-0.8224	-4.9865	< .001	-1.000--0.551

Table 7 presents the Tau-U findings for participant 6 at the pre-test, during-intervention, and post-test stages. The statistical significance (Tau-U = 1.00, Z = 6.06, p < .001) between the pre-test and the during-intervention was very large and significantly positive. This implies that AI-based memory tasks also occurred strongly and immediately. An analysis of pre-test to post-test also revealed a big and significant effect (Tau-U = 0.832, Z = 5.04, p = .001) and the most of the gains were retained after the intervention. Nevertheless, the comparison of the during-intervention and post-test levels showed a marked difference (Tau-U = -0.822, Z = -4.99, p < .001), with active AI support yielding the highest performance. This reduction is probably because of the elimination of structured prompts and feedback, as opposed to the loss of learning, as the post-test performance was better than the baseline.

Findings

The results indicate that AI-mediated memory activities produced significant and vivid improvements in memory functioning among the respondents. A change pattern means that the intervention was rather significant and yielded immediate benefits when AI was actively used and, although less impressive, extra benefits after the intervention. The differences between Tau-U in the pre-test/during-intervention comparisons follow a similar pattern, meaning that there is a significant change in memory performance as a result of artificially potentiated assistance of AI. The implications of these are that programmed cues, adaptive responses, and rehearsal that are involved in AI tasks can support the rapid development of memory abilities. These effects were consistent across phases, suggesting that the intervention was elaborating on core memory processes rather than producing task-specific gains. Pre-test to post-test comparisons also suggest that the improvements were maintained primarily when the participants were put back in the regular classroom conditions. However, post-test performance was higher than at the time of the intervention, albeit at a significantly lower level and still significantly higher than at baseline, confirming the test-retest reliability of learning during the period of active AI use. The perceived decline in the between the during-intervention and the post-test condition is due to the loss of the continuous AI scaffolding and not the learning. During intervention, immediate feedback, guided cues and structured opportunities of retrieval facilitated performance. When these supports were removed, participants relied more on independent recall, resulting in lower yet consistent performance. This tendency underlines the importance of AI as the external cognitive scaffold that facilitates performance with the help of its support and storing of the strategies of memory. By and large, the findings assist in evaluating the usefulness of AI-assisted memory instruction and the necessity to use maintenance or fading strategies to gain independence in the long term.

CONCLUSION

In the current study AI-based memory activities were analyzed regarding their effects on boys with mild intellectual disabilities and it was observed that there was a steady improvement pattern during active intervention and partially maintained after the withdrawal. This trend is consistent with the previous studies which have shown that AI-based learning systems are the most effective when structured practice, adaptive feedback, and personalized pacing are implemented, instead of unstructured exposure (Rokhsari, 2025). There is evidence that systematic reviews indicate that such design features directly facilitate memory-related tasks, especially encoding and retrieval, resulting in credible improvements of immediate and delayed performance (Cha, 2024). The current positive intervention effects of the study are consistent with the results that indicate that AI tools produce positive memory results when serving as instructional aids that are integrated into pedagogically guided activities. These effects are cognitively consistent with the cognitive load theory and the principles of multimedia learning, which suggest minimizing the extraneous load and facilitating germane processing with the help of guided cues and feedback (Mayer, 2020; Sweller et al., 2011). The AI-based systems are specifically more suited to apply these principles by increasing and decreasing the task difficulty and pacing to the performance of the learners (Rokhsari, 2025). This downward trend after the removal of the AI support is actually a trend that is commonly found in the literature where the most success is seen when actively participating with adaptive systems. Studies regarding cognitive offloading indicate that students can also use external assistance in the process of intervention, which leads to poorer performance when these prompts and feedback are discontinued (Risko & Gilbert, 2016). Notably, the post-test results above baseline obtained in this research study suggest that learning was not lost after the test, but instead, this result supports the readings that AI scaffolding can aid in partial internalization of memory skills (Rokhsari, 2025). Regarding special education, these results are consistent with the existing research indicating that people with intellectual disabilities were found to learn optimally in structured, repetitive learning environments that are externally reinforced, especially in memory development (Vicari et al., 2016). Research on mobile and AI-based cognitive rehabilitation also demonstrates a positive impact on memory and other cognitive abilities in a systematic and individualized approach to interventions (Hilario et al., 2023; Cha, 2024). The current research builds upon this evidence by showing the same effects in a school-based special education setting by using a single-subject design. In general, the results indicate that memory interventions based on AI have the potential to be used as an effective cognitive scaffold in the special education environment. Nevertheless, the post-intervention decrease observed demonstrates the relevance of the planned maintenance or fading strategies in alleviating the decline in independent memory performance with the course of time, which are recommended in the literature of instructional design and cognitive rehabilitation (Cha, 2024; Rokhsari, 2025).

Recommendations

Based on the findings, the study makes some recommendations that AI-based apps can improve teaching practice and teaching methods. Special education teachers can further improve children's memory skills with the help of these apps. When teachers teach children with AI support in their daily classes, children will show definite improvement, in a way that they can organize and guide these children. In such settings, incorporating AI activities with conventional teaching activities can be used to improve learning and skill reinforcement. In order to use technology-enhanced instruction, professional development is necessary to provide adaptive learning features and training to the teacher to track the progress. School administrators are also advised to take steps to use modern technology in their institutions that will help and support these children in enhancing their academic and cognitive skills. This study also provides an avenue for computer software developers to work on AI applications that are aligned with our educational curriculum. They can create applications that ensure students' independence and provide them with facilities that are easy to use. Most importantly, with the help of these applications, parents can also educate their children at home. The future of AI in education requires more research and investigation into the potential long-term consequences of AI, comparisons between different AI platforms, and the outcomes of AI in more diverse and larger groups of students.

Limitations

This study has some constraints that ought to be mentioned. To start with, the single-subject design has a small sample size, which has limited statistical power and minimizes the generalizability of the results. However, the small sample size does not allow for detecting a more subtle but potentially significant impact, even though the effect-size estimates indicated significant intervention-related change. External validity would be strengthened by using larger, more diverse samples to replicate the findings. Second, the research was conducted in a single location and lacked a prolonged maintenance or follow-up period, which limits the extrapolation of the results to long-term retention of memory improvements beyond the immediate post-intervention period. Third, although outcome assessment was based on objective, task-based measures, neither participants nor implementers could be blinded to the intervention, so there was a risk of expectation effects. Lastly, there were no formal measures for the treatment's acceptability or social validity.

Implications

This study has implications for the practice, research, and policy of special education settings. Based on the findings, we can effectively implement AI-based memory exercises in classroom instruction as organized mental support of boys with mild intellectual disabilities. Educators can apply AI tools to deliver personalized practice, immediate feedback, and re-retrieval options, especially to those learners with the need to have constant scaffolds to aid memory formation. The recorded slowdown following withdrawal underlines the necessity to adopt gradual fading and maintenance approaches as opposed to an immediate stop of AI help. To the researchers, the research highlights the importance of single-subject designs when studying individual learning processes in technology-assisted interventions. Future studies must build up on this study by adding longer periods of maintenance, comparison, and standard memory tests to gain a clearer insight into the effects of long-term retention and generalization. A more precise analysis of the differences in effects of certain memory subdomains can also help achieve a better understanding of what AI properties are the most efficient. The policy level reveals that the results can justify the introduction of pedagogically controlled AI tools into the special education programs under the condition that their application is properly coordinated with the instructional objectives and accompanied by the teacher training. The policymakers need to highlight AI as a facilitative instructional resource and not a substitute to teacher led instruction to make sure AI and teacher led instruction are woven integratively in special education settings.

Future Research

The AI-based memory interventions should be investigated in studies in the future with more heterogeneous and larger samples to enhance the context of generalizability. The long-term retention after withdrawal of AI support would need protracted maintenance and post follow-up to obtain the same. The unique inputs of AI-based activity need to be presented with the comparative designs with other teaching tools. Standardized memory tests and measures of social validity should also be used in future research to augment practical and empirical inferences.

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