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Exploring the effectiveness of a novel memory training program for students with learning disabilities in the United Arab Emirates: investigating the role of gender differences

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Introduction: The present research aims to investigate the efficacy of a newly developed memory training strategy on improving the memory capabilities of students with learning impairments.

Methods: Involving thirty male and female students with learning challenges, the study divided participants into experimental and control groups, with the former undergoing a novel memory training program. Memory was evaluated before and after a 3-month training period using a recall assessment technique developed from prior studies.

Results: Findings indicated statistically significant differences in memory scores between the experimental and control groups on the novel memory scale (total score) and its aspects (Auditory, Visual, and Visual kinesthetic memory), with improvements noted only in the experimental group. Gender did not significantly impact the scores, and there was no significant interaction between gender and group on training outcomes, suggesting the training's universal applicability.

Discussion: The study demonstrates that a novel memory training course can significantly enhance memory functions in students with learning impairments, irrespective of gender. These results offer promising directions for integrating cognitive training into educational strategies to support students facing learning challenges.

KEYWORDS

memory training, learning disabilities, resource rooms, auditory memory, visual memory, gender impacts

Introduction

Cognition and memory are fundamental components of the learning process in education psychology (Eysenck and Keane, 2018; Rao et al., 2023). However, students with learning disabilities often face challenges in acquiring knowledge and skills despite the implementation of various interventions (Fletcher et al., 2018; Zakopoulou et al., 2019). This may be attributed to the fact that many interventions do not target underlying cognitive impairments such as memory problems (D'Ostilio and Garraux, 2012; Gathercole and Alloway, 2023). Thus, a novel intervention that focuses on ameliorating memory impairments in students with learning disabilities may be an effective approach to enhance educational performance. This paper aims to explore this intervention and compare it to existing interventions for learning disabilities.

Cognition and memory in the context of educational psychology

Cognitive theory is often used in education to elucidate the process of learning, highlighting the significance of an individual's behaviors, thoughts, previous experiences, and cognitive abilities. This notion has a substantial effect on both the instructor and the learner (Trinidad, 2020). Modern cognitive theory emphasizes the interrelation of attention, perception, working memory, and long-term memory in education (Chang et al., 2019; Cicekci and Sadik, 2019; Cortés Pascual et al., 2019; Lodge and Harrison, 2019; Abo Hamza and Helal, 2021; Abushalbaq et al., 2021; Berkowitz et al., 2022). Attention serves as the primary cognitive filter for external inputs, impacting perception and learning (Lodge and Harrison, 2019). Perception involves the organization and interpretation of sensory data to create meaningful ideas. Working memory processes and manipulates information before storing it in long-term memory for future retrieval (Zakopoulou et al., 2019; Melton et al., 2023).

Memory plays a critical role in the learning process, serving as the foundation for acquiring and retaining knowledge (Varao-Sousa and Kingstone, 2015; Rao et al., 2023). Psychologists actively explore the neuromolecular basis of memory, investigating how interactions between different brain regions and neurotransmitters, like glutamate, influence learning outcomes (McGaugh, 2016). Successful learning necessitates encoding information into memory, as evidenced by the inability to recall information often indicating an unsuccessful learning experience (Hering et al., 2018). Therefore, remembering can be viewed as a product of learning, significantly influenced by attentional and perceptual processes that guide what information is successfully encoded and retained (Markant et al., 2016; Hering et al., 2018).

Cognitive theory has offered useful insights into attention, perception, and memory's involvement in learning but has been criticized for neglecting important parts of the learning process. Critics contend that the narrow emphasis on individual cognitive processes in this approach overlooks the substantial impact of social and cultural environments on individuals' learning, as stated by Bredo (2017). Research has shown that collaborative learning spaces improve student engagement, motivation, and critical thinking abilities (Swanson, 2020). Cognitive theory recognizes memory's importance in learning but may overlook emotions' influence on memory encoding and retrieval (Hering et al., 2018). Educators may enhance learning settings by combining cognitive tactics with social, cultural, and emotional factors, leading to a more comprehensive and efficient educational approach (Darling-Hammond and Bransford, 2005; Cortés Pascual et al., 2019; Lodge and Harrison, 2019; Berkowitz et al., 2022).

In conclusion, cognitive theory has contributed significantly to our understanding of the role of attention, perception, and memory in the learning process. However, its limitations regarding social and cultural contexts, collaborative learning, and the impact of emotions on memory and learning highlight the need to consider a broader range of factors that may influence the learning process.

Learning disabilities: definition and interventions

Recent research on learning disabilities and memory has focused on a range of topics, including the neurobiological basis of these conditions, the impact of technology on memory and learning, and potential interventions. In a study that was carried out by Liu et al. (2022) study on changes in functional connectivity in children with dyslexia during visual and phonological processing tasks, functional magnetic resonance imaging (fMRI) was utilized to investigate the neural networks that are involved in the processing of visual and phonological information in children who have dyslexia. The authors found that children with dyslexia showed altered functional connectivity in brain regions associated with phonological processing, suggesting that dyslexia may be related to abnormal neural connectivity.

The concept of "learning disabilities" was first introduced by the researcher Kirk in 1962 (Robaey, 2013) and since then, many scholars have emphasized the need to focus not just on academic learning disabilities, but also on developmental learning disabilities, which are often the root cause of academic underperformance (Fletcher et al., 2018). Failing to address or treat developmental learning disabilities in early childhood can subsequently result in academic disabilities (Grigorenko et al., 2020). Therefore, addressing academic learning disabilities often involves treating the underlying developmental impairments, such as short or long-term memory disorders, as memory is a crucial component of the learning process (Collins and Frank, 2012; Rao et al., 2023).

There are a range of interventions available for individuals with learning disabilities and memory problems, including educational interventions, cognitive-behavioral therapy, and medications. Similarly, cognitive-behavioral therapy can be effective for individuals with memory problems (Akbarian et al., 2015; Hering et al., 2018).

Another study by Siok et al. (2009) explored the use of multisensory learning to enhance memory in children with dyslexia. The program involved using visual, auditory, and kinesthetic modalities to teach reading and writing skills. The results showed that the program was effective in improving memory and academic performance. A study by Lervåg and Hulme

(2009) and Hering et al. (2018) investigated the effectiveness of cognitive training on working memory in children with dyslexia. The program involved working memory training tasks, such as remembering sequences of numbers and letters. The results showed that the program was effective in improving working memory and academic performance.

The majority of ordinary students in the early stages of life can memorize songs and chants, and count automatically before they enroll in formal education, but children with learning disabilities fail to do so, despite their training in kindergarten (Geary et al., 2012; Abushalbaq et al., 2021). As for the stages of formal education, the average student resorts to devising plans that help them acquire information, including memorizing new words or numbers by linking them to personal information they have previously acquired, while students with learning disabilities are often unable to acquire much information because of their poor memory.

Individuals with learning disabilities often suffer from auditory and visual memory impairment (Gray et al., 2019). Learning disabilities can impact mathematical achievement, and that teachers of students with learning disabilities indicate in their reports that students with learning disabilities do not remember the spelling of words, mathematical equations, and instructions, and they also indicate that students with learning disabilities fail to use strategies used by ordinary students. Furthermore, the difficulty of remembering among students with learning disabilities is caused by language impairment, so remembering verbal materials is difficult for them.

Mnemonic strategies involve the use of mental imagery, associations, and other memory aids to assist students encode information more effectively. According to several studies by Jaroslawska and colleagues (Jaroslawska et al., 2015, 2016, 2018), mnemonic strategies can be effective in improving memory performance in students with learning disabilities. For example, Flavell and Wellman (2019) found that teaching students with learning disabilities how to use visual and verbal imagery to encode information improved their recall of written texts. Another study by Lazzaro et al. (2021) found that teaching students with learning disabilities how to use elaborative and organizational strategies to encode information improved their recall of word lists.

Working memory refers to the ability to hold and manipulate information in short-term memory. Working memory problems are common in students with learning disabilities, and interventions that aim at improving working memory have been shown to have positive effects on academic performance. In a review by Alloway (2020) and Rao et al. (2023), working memory training was found to be effective in improving working memory and academic achievement in students with learning disabilities. For example, some studies found that working memory training improved working memory performance and reading comprehension in children with dyslexia (Dahlin, 2011; Luo et al., 2013; Maehler et al., 2019; Abo Hamza and Helal, 2021; Abushalbaq et al., 2021; Ren, 2021; Rao et al., 2023).

Environmental modifications can be used to reduce distractions in the learning environment and provide visual aids that can support memory performance in students with learning disabilities. According to a review by Zhang et al. (2018), environmental modifications can be effective in improving memory performance in students with LDs. Overall, the literature suggests that a variety of interventions and strategies, including mnemonic strategies, working memory training, social skills interventions, and assistive technology, can be effective in improving memory for students with learning disabilities.

TABLE 1 Study participants according to gender.

Groups	Male	Female	Total
Experimental	6	9	15
Control	6	9	15
Total	12	18	30

Current study

Literature on the area of special education indicates that students with learning disabilities commonly struggle with memory problems, which can limit their ability to learn. Teachers who work with such students often report that their students have a low capacity for retention, which often burden the teachers as they have repeat things in class. Since memory disabilities are a common developmental learning issue that underlies many academic disabilities, educators and special education workers should develop training programs aimed at improving memory and investigate the effectiveness of such programs. This study aimed to investigate the effect of a memory training program in improving the memory of students with learning disabilities. Further, we will investigate whether there are any gender differences in relation to the impact of memory training What is the effect of a proposed training program on improving the memory of students with learning disabilities?

Method

The researcher employed a semi-experimental approach involving two groups—a control group and an experimental group. A pre- and post-measurement was conducted to assess the extent of improvement in memory skills in both groups following training (or lack of training in the control group).

Participants

The study sample included 30 male and female fifth-grade students with learning disabilities who were enrolled in resource rooms. The sample distribution between the experimental and control groups is shown in Table 1.

Students characteristics

Identifying students with learning disabilities, according to the Ministry of Education's guidelines, highlights the many challenges these students face in their schooling. These challenges span different areas like reading, writing, and math, each posing its own unique obstacles along their educational journey. But despite these differences, one shared struggle among these students is with memory, which significantly affects their academic performance. Memory is crucial for learning and remembering information, forming the foundation for academic success. For students dealing with learning disabilities, issues with memory make it even harder for them to navigate their schoolwork. Problems with remembering, storing, and recalling information make it tough for them to grasp new concepts, remember important details, and use what they've learned effectively. In reading, for instance, poor memory might make it difficult to remember key information from texts, follow stories, or recall vocabulary and grammar rules. Similarly, in writing, memory problems can disrupt how they organize their thoughts, affecting the clarity of their writing. And in math, struggles with memory might mean they have trouble remembering important concepts or how to solve problems, making it hard to apply math skills to real-world situations or complex calculations. Memory issues don't just affect students' academic performance. They can also impact other parts of their lives, like their self-esteem, motivation, and social interactions. Constantly struggling with memory can lead to feelings of frustration, inadequacy, and isolation, making the emotional toll of learning disabilities even heavier.

Memory training program implementation

In the process of applying the recall test, a collaborative effort involving the first authors and three teachers from resource rooms in the students' regular schools was established. This team approach ensured a diverse range of perspectives and expertise in conducting the assessment. To maintain consistency and accuracy in administering the test, the teachers underwent an extensive 3 h training session, covering the procedural intricacies of test administration and grading across various dimensions. Additionally, meticulous preparation of the required test materials was undertaken to ensure uniformity and relevance to the study's objectives. Each student underwent individual testing sessions, allowing for personalized attention and minimizing external distractions. The allotted time frame of 35–40 min for completion of the test was carefully determined to strike a balance between thorough assessment and respect for the students' attention spans. Overall, these comprehensive procedures were implemented to guarantee standardized administration, reliable evaluation, and valid results in assessing students' recall abilities.

Measures

Memory test for students with learning disabilities

To assess the memory abilities of students with learning disabilities, the first author of the current study created a memory test after extensive review of previous studies (Cusimano, 2003, 2005). The test focused on measuring auditory, visual, and visual-kinesthetic recollection and used vocabulary from fourth and fifth-grade textbooks. The first author then conducted an exploratory study to ensure the paragraphs were appropriate for the target age group and to check the clarity of the instructions and the frequency of common words. The test was administered to both the experimental and control groups before and after the study, and the first author followed a specific set of steps to prepare and administer the test.

TABLE 2 Dimensions and characteristics of the memory test.

Dimension	Test name	Items	Max. score
Auditory memory	Numbers	14	70
	Letters	12	54
	Words	15	60
	Sentences	8	50
	Associated memory	10	7
Visual memory	Picture-number	10	10
	Word-number	10	10
	Face-detection	10	10
	Word-detection	10	10
Visual kinesthetic memory	Visual motor repercussions	3	60
	Remember and produce shapes	14	14
Total		116	355

The process involved three steps: (a) collecting samples from previous tests; (b) developing new paragraphs based on the subject literature, and (c) presenting the test to a group of specialists to assess its suitability in terms of the dimensions it measures, linguistic wording, and target age group. Some paragraphs were deemed inappropriate and were removed, while others were modified or rephrased. The test includes three dimensions, which are listed in Table 2.

Test experiment

An exploratory sample of fifth-grade children consisting of 55 male and female students was used to test the test items. Among the sample, 25 students had learning disabilities, while 30 were considered healthy normals. The sample was selected randomly from a different study group to ensure objectivity. The test was designed with clear instructions and appropriate language for the target age group, and it took around 35–40 min to complete when administered individually. We found that the wording and language of the test's paragraphs were suitable, and the test was easy to apply within the allotted time. The validity of the test was verified in two ways:

Content validity

A group of ten arbiters, consisting of university professors and academic staff who specialize in measurement and

TABLE 3 Means and standard deviations of discriminatory validity on the total recall test and the subtests.

Dimension	Test name	Students				*t*-test	Sig.
		LD		Regular			
		Mean	SD	Mean	SD		
Auditory memory	Numbers	20.63	5.145	35.53	4.718	11.788	000.0
	Letters	19.77	5.800	30.07	3.956	7.103	000.0
	Words	21.24	4.977	30.30	3.313	8.061	000.0
	Sentences	20.00	3.959	27.23	3.081	7.070	000.0
	Associated memory	3.88	0.999	4.60	0.930	3.126	0.003
Visual memory	Picture-number	4.76	1.451	7.70	0.651	9.969	000.0
	Word-number	4.80	1.527	7.86	0.740	9.593	000.0
	Face-detection	5.36	1.075	8.43	8.433	13.560	000.0
	Word-detection	5.88	0.927	8.53	0.507	13.455	000.0
Visual kinesthetic memory	Visual motor repercussions	25.52	3.214	33.96	4.759	8.013	000.0
	Remember and produce shapes	5.60	1.322	9.13	1.332	9.825	000.0
All Items		139.52	22.247	203.13	17.097	11.986	000.0

TABLE 4 Distribution of the stability sample members according to the variables of category and gender.

Group	Gender	Number	Grade
Students with learning disabilities	Male	8	5th
	Female	8	5th
Normal students	Male	8	5th
	Female	8	5th
Total		32	

TABLE 5 Stability coefficients of test dimensions.

Dimension	Cronbach alpha	Dimension	Cronbach alpha
Auditory memory	0.87	Visual kinesthetic memory	0.82
Visual memory	0.86	All items	0.89

evaluation, special education, and educational psychology, were given the test. Additionally, the test was given to two educational supervisors who had a master's degree in special education and between 3 and 4 years of experience supervising teachers with special needs. Lastly, a group of resource room teachers from a collection of schools were also presented with the test.

Discriminatory validity

To establish the discriminatory validity of the test, it was administered to a group of fifth-grade students consisting of 25 male and female students with learning disabilities, and 30 male and female students who were considered ordinary. These students were randomly selected and they are different from the study sample. The results indicated that the test effectively distinguishes between the two groups with a significance level of $\alpha \leq 0.000$, favoring the group of ordinary students. To confirm the discriminatory validity, the mean and standard deviation were calculated for each group's total scores on the scale, as well as for each sub-scale, which are reported in Table 3. As shown in Table 3, ordinary students outperformed students with learning disabilities on both the total score and individual sub-tests of the remembering test. The calculated value of "T" for all tests reached a statistically significant level, indicating that the test can effectively differentiate between the performance of normal students and those with learning disabilities. This supports the discriminatory validity of the test and is deemed acceptable for the study's objectives.

Reliability

For the purpose of testing the stability of the test, a sample of 32 students was randomly selected from those who were previously administered the test to establish its discriminatory validity. The sample included 16 male and female students with learning disabilities, and 16 normal students. These students were chosen from outside the study sample. Table 4 displays the distribution of the reliability sample.

To assess the stability of the test, it was administered to an exploratory sample shown in Table 4, and then repeated after 10 days using the same method. The overall stability coefficient for the test was found to be 0.87, which is considered acceptable and statistically significant at the level of 0.001. This indicates that the test is appropriate for the purposes of the study. The stability coefficients for each sub-dimension of the test are presented in Table 5.

TABLE 6 Study design LD refers to learning difficulty.

Group	Category	Posttest	Treatment	Pretest
Experimental	LD students	O2	Yes	O1
Control	LD students	O2	-	O1

TABLE 7 The arithmetic means and standard deviations of the total scores on the pre and posttest for the variables of group and gender.

Group	Test		Gender		
			Male	Female	Total
Experimental	Pre	Mean	203.166	203.000	203.08
		SD	19.049	23.864	21.238
	Post	Mean	272.419	272.495	272.457
		SD	11.082	12.290	11.481
Control	Pre	Mean	203.150	203.333	203.24
		SD	17.672	24.163	21.905
	Post	Mean	203.307	203.833	203.513
		SD	17.672	24.163	20.860

Procedures for applying the test

The recall test was administered by the first authors as well as three teachers from resource rooms in regular schools where the participating students attend. These teachers underwent a 3 h training session on how to conduct the test and calculate grades on each of its dimensions. The required materials for the test paragraphs were also prepared. The test was administered individually and took between 35 and 40 min to complete.

Correcting the test

The final version of the test, after conducting validity and reliability procedures, consists of eleven sub-tests distributed across three dimensions: auditory, visual, and visual-kinesthetic memory. The student's grades for each dimension are collected separately. The scores for each dimension are as follows: 241 marks for auditory memory, 40 marks for visual memory, and 74 marks for visual-kinesthetic memory. These dimensional marks are combined to form the total mark for the test, where the lowest mark is zero and the highest mark is 355. This study is categorized as a quasi-experimental study because the participants were intentionally chosen and divided into two groups (experimental and control), both consisting of fifth-grade students. The experimental group underwent a training program, while the control group did not. The study utilized a semi-experimental design with an equal groups design that included a pre-test and post-test, as presented in Table 6.

The mean scores of the students in the groups were compared using the analysis of covariance (ANCOVA) method to examine the impact of the training program on enhancing the memory of the participants.

TABLE 8 Covariance analysis of the effect of group and gender and the interaction between them in the total memory test.

Source of variance	Sum off squares	Degree of freedom	Mean of squares	*f*	Sig.
Pretest	10,732.546	1	10,732.546	168.066	000.0
Gender	0.713	1	0.713	0.001	0.916
Group	59,320.721	1	59,320.721	928.931	0.000
Gender x group	0.328	1	0.328	005.0	0.943
Error	2,873.659	45	63.859	-	-
Total	72,844.980	49	-	-	-

TABLE 9 The arithmetic means and standard deviations of the auditory recall dimension according to the variables of gender and group on the pre and posttests.

Gender	Group	Experimental		Control	
		Pre	Post	Pre	Post
Male	Mean	131.230	184.000	131.86	131.769
	SD	18.489	12.254	13.545	13.887
Female	Mean	131.416	183.250	132.666	132.583
	SD	18.652	9.554	17.680	17.588
Total	Mean	131.320	183.640	132.240	132.160
	SD	18.176	10.820	15.335	15.439

Results

The purpose of the current research was to examine how a training program could improve the memory of fifth-grade students with learning disabilities. The study intentionally selected (30) male and female students with learning disabilities from resource rooms. The participants undertook a pre-test before the training program and a post-test after it ended. The data collected from the program were analyzed using the analysis of covariance (ANCOVA) method. The study calculated the mean and standard deviation of the pre-test and post-test scores for both the experimental and control groups (see Table 7).

Table 7 presents the average scores for the experimental and control groups in both the pre-test and post-test. The experimental group had an average score of (203.08) on the pre-test, while they scored (272.457) on the post-test. On the other hand, the control group had an average score of (203.150) on the pre-test and (203.307) on the post-test. It is worth noting that the average score for males in the experimental group on the post-test was (272.419), while the average score for males in the control group was (203.307). Also, the average score for females in the experimental group on the post-test was (272.495), while the average score for females in the control group was (203.833). To investigate the significance of these differences and determine their direction, an analysis of covariance (ANCOVA) was conducted to examine the effect of group and gender as well as the interaction between them. The results of this analysis are presented in Table 8.

TABLE 10 Covariance analysis of the effect of group and gender and the interaction between them in the auditory memory test.

Source of variance	Sum off squares	Degree of freedom	Mean of squares	*f*	Sig.
Pretest	6,100.771	1	6,100.771	113.317	0.000
Gender	1.163	1	1.163	0.022	0.884
Group	33,815.114	1	33,815.114	628.092	0.000
Gender x group	4.044	1	4.044	0.075	0.785
Error	2,422.704	45	53.838	-	-
Total	41,658.500	49	-	-	-

Table 8 indicates that the mean score differences between the experimental and control groups are statistically significant with a *f*-value of (928.931), which is significant at a level of significance of (0.000), lower than the predetermined level of significance in this study ($\alpha \leq 0.05$). Therefore, the null hypothesis is rejected, and the alternative hypothesis is accepted, indicating that there are significant differences at a significance level of ($\alpha \leq 0.05$) in the scores obtained on the memory test after the training program between the members of the experimental group (who received memory training) and the members of the control group (who did not receive memory training), and in favor of the experimental group.

Table 8 also shows that the differences between males and females in memory scores were not statistically significant, as the f value was only (0.001) with a significance level of (0.916), which is higher than the significance level set for this study ($\alpha \leq 0.05$). This means that there is no significant difference in memory between males and females. Similarly, the interaction between the effect of the training program and gender did not show significant differences either, as the *f* value was (0.005), with a significance level of (0.943), which is higher than the significance level set for this study ($\alpha \leq 0.05$). Therefore, the null hypothesis is accepted and the alternative hypothesis is rejected. This conclusion is also supported by looking at each dimension of the memory scale separately.

First dimension: auditory memory

Table 9 presents the average scores and standard deviations of the students' performance in the auditory memory test. The total average score for the pre-test was (131.230), while the total average score for the post-test was (184.000). As for the average score for the control group, it was (132.240) for the pre-test and (132.160) for the post-test.

Table 10 presents the arithmetic means and standard deviations of the auditory memory test scores for males and females in both the experimental and control groups. The results show that the average performance of males in the control group on the pre-test was (131.86) compared to (131.769) on the post-test. In contrast, the average performance of females in the experimental group on the pre-test was (131.416), compared to (183.250) on the post-test. Furthermore, the average performance of females in the control group on the pre-test was (132.666) compared to (132.583) on the post-test. The analysis of covariance (ANCOVA) was used to test the significance of the differences between the arithmetic means and determine their direction, taking into account the effects of group, gender, and their interaction. The results of this analysis are shown in Table 10.

TABLE 11 The arithmetic means and standard deviations of the pre and post visual memory dimension according to the variables of gender and group.

Gender	Group	Experimental		Control	
		Pre	Post	Pre	Post
Male	Mean	30.461	36.076	30.307	30.538
	SD	3.502	1.705	4.090	4.033
Female	Mean	30.833	36.666	30.583	30.583
	SD	2.124	0.887	1.831	1.621
Total	Mean	30.640	36.360	30.440	30.560
	SD	2.870	1.380	3.150	3.056

Table 10 shows that there are statistically significant differences at the significance level of ($\alpha \leq 0.05$) ascribed to the effect of the group variable, as indicated by the value of *P* (628.092) at the level of (0.000). These differences were in favor of the experimental group, which received training on the training program. However, there were no statistically significant differences at the significance level of ($\alpha \leq 0.05$) attributed to the effect of the gender variable, as indicated by the value of P (0.022) at the level of (0.884). Additionally, there were no statistically significant differences at the significance level of ($\alpha \leq 0.05$) due to the interaction between gender and group, where the *P* value was (0.075) at (0.785).

Second dimension: visual memory

Table 11 shows the mean scores and standard deviations of students' performance in the visual memory test. The pre-test mean score for the experimental group was (30.640) compared to (36.360) for the post-test. In contrast, the total mean score for the control group was (30.440) compared to (30.560) for the post-test. Additionally, the table presents the mean scores and standard deviations of males and females in the visual memory test. The total mean score for males in the experimental group was (30.461) compared to (36.076) for the post-test, and for males in the control group, the pre-test mean score was (30.307) compared to (30.538) for the post-test. The total mean score for females in the experimental group was (30.833) compared to (36.666) for the

TABLE 12 Covariance analysis of the effect of group and gender and the interaction between them in the visual memory test.

Source of variance	Sum off squares	Degree of freedom	Mean of squares	*f*	Sig.
Pretest	171.037	1	171.037	79.592	0.000
Gender	0.162	1	0.162	0.076	0.785
Group	402.762	1	402.762	187.427	0.000
Gender x group	0.732	1	0.732	0.341	0.562
Error	96.701	45	2.149	-	-
Total	690.420	49	-	-	-

TABLE 13 The arithmetic means and standard deviations of the pre and post visuospatial recall dimension according to the variables of gender and group.

Gender	Group	Experimental		Control	
		Pre	Post	Pre	Post
Male	Mean	41.307	52.230	41.166	41.166
	SD	4.837	4.265	9.456	8.515
Female	Mean	40.916	52.583	40.000	40.538
	SD	4.962	5.648	5.400	5.379
Total	Mean	41.120	52.400	40.560	40.840
	SD	4.798	4.873	7.478	6.914

post-test, and for females in the control group, the pre-test mean score was (30.583) compared to (30.583) for the post-test.

An analysis of covariance (ANCOVA) was conducted using Table 12 to determine the significance and direction of the differences between the arithmetic means of the visual memory test, considering the effect of group, gender, and their interaction.

Table 12 shows that there are statistically significant differences at the significance level of ($\alpha \leq 0.05$) due to the effect of the group variable, with a *P* value of (0.000) and a value of (187.427). These differences are in favor of the experimental group, which underwent training using the program. However, there were no statistically significant differences at the significance level of ($\alpha \leq 0.05$) attributed to the effect of the gender variable, with a *P* value of (0.076) and a level of (0.785). Additionally, there were no statistically significant differences at the significance level of ($\alpha \leq 0.05$) attributed to the interaction between gender and group, where the *P* value was (0.341) at (0.562).

Third dimension: visual kinesthetic memory

Table 13 presents the average scores and standard deviations of students' performance on the visual-motor memory test. The mean score for the experimental group was (41.120) in the pre-test and (52.400) in the post-test. On the other hand, the mean score for the control group was (40.560) in the pre-test and (40.840) in the post-test. Table 13 displays the means and standard deviations of students' scores on the visual-motor memory test, including the average scores of males and females. For the experimental group, the average score for males before the training was (41.307), while after the training, it increased to (52.230). As for the control group, the average score before and after the training remained the same at (41.166).

Table 14 displays the arithmetic means and standard deviations of the visual-motor memory test performance for both males and females, where the experimental group had a higher arithmetic mean of (41.307) before training and (52.230) after training for males, and (40.916) before training and (52.583) after training for females. In contrast, the control group had lower arithmetic means of (41.166) before training and (41.166) after training for males, and (40.000) before training and (40.538) after training for females. To assess the significance and direction of these differences, an analysis of covariance (ANCOVA) was utilized to account for the impact of both group and gender, as well as their interaction, as presented in Table 14.

Table 14 shows that the effect of the group variable is statistically significant at the level ($\alpha \leq 0.05$), with a value of f at (0.000) indicating that the experimental group (who underwent the training program) performed significantly better. On the other hand, the effect of the gender variable is not statistically significant at the level ($\alpha \leq 0.05$), as the value of P was (0.091) at the level of (0.764). Furthermore, there were no statistically significant differences at the level of significance ($\alpha \leq 0.05$) due to the interaction between gender and group, with a *P* value of (0.034) at the level (0.854).

Discussion

The objective of this study was to examine how a novel memory training program could enhance memory among fifth-grade students with learning disabilities. The newly developed program, created by the first author of this study, comprised of various exercises and techniques designed to boost students' ability to recall information. We used analysis of covariance (ANCOVA) to compare the performance of the experimental and control groups. Results indicated that there were significant differences in the extent of remembering information between the two groups of students, as the experimental group showed superior performance. The post-test results also confirmed that the experimental group, who underwent the training program, had significantly better outcomes than the control group, who did not undergo any training.

The observed increase in the memory skills of the experimental group can be attributed to their participation in the memory

TABLE 14 Covariance analysis of the effect of group and gender and the interaction between them in the visual-motor memory test.

Source of variance	Sum off squares	Degree of freedom	Mean of squares	*f*	Sig.
Pretest	830.518	1	830.518	42.296	0.000
Gender	1.786	1	1.786	0.091	0.764
Group	1,563.571	1	1,563.571	79.629	0.000
Gender x group	0.677	1	0.677	0.034	0.854
Error	883.604	45	19.636	-	-
Total	3,387.780	49	-	-	-

improvement training program. The program was designed to enhance their memory skills through the use of specific memory improvement strategies, and the training activities they engaged in during the sessions were tailored to their individual learning needs, enabling them to better remember and retain the information they encountered during their education. The clear educational procedures taught during the program enabled the experimental group to improve their memory performance, and they were able to master the memory strategies by participating in all components of the training, including instruction, feedback, behavioral practice, reinforcement, modeling, and homework.

The implementation of individualized education and small-group instruction (4–5 students per group) within the experimental group may have provided better opportunities for students to engage in educational activities and facilitated closer monitoring and support from the teacher. This likely contributed to the observed improvement in the students' memory skills. The effectiveness of the program may also be attributed to factors such as students' commitment to attending the training sessions and completing homework with care, as well as the friendly and supportive learning environment created for students with learning disabilities.

While memory training programs have shown promise in enhancing memory skills in students with learning disabilities, it is important to note that not all memory training programs are created equal. A meta-analysis by Peijnenborgh et al. (2016) found that the effectiveness of memory training programs varied greatly depending on the specific training methods and techniques used. Moreover, the effects of memory training programs on long-term memory and academic achievement are still uncertain, and there is a need for further research to determine the long-term effects of memory training programs (Peijnenborgh et al., 2016).

The current study's memory training program was designed to address the underlying cognitive memory problems in students with learning disabilities, which are known to negatively impact their educational performance (Fletcher et al., 2018). The program incorporated several techniques and exercises aimed at enhancing the students' ability to encode and retrieve information, such as visualization techniques, mnemonic devices, and repeated practice (Peijnenborgh et al., 2016; Kelly and Kramer, 2020). The success of the program may also be attributed to the implementation of individualized education and small-group instruction, with 4–5 students per group. This approach provided better opportunities for students to engage in educational activities and facilitated closer monitoring and support from the teacher. The friendly and supportive learning environment created for students with learning disabilities also likely contributed to the effectiveness of the program.

While the results of the current study are promising, there are limitations that need to be considered. The sample size was relatively small, and the study did not assess the long-term effects of the memory training program. Moreover, the study did not control for factors such as students' motivation and engagement in the program, which could have influenced the results. Further research is needed to determine the long-term effects of memory training programs and to identify the specific training methods and techniques that are most effective for enhancing memory skills and academic achievement in students with learning disabilities.

In conclusion, the current study provides preliminary evidence of the effectiveness of a novel memory training program in enhancing the memory skills of fifth-grade students with learning disabilities. The program's incorporation of memory enhancement techniques and exercises, along with individualized education and small-group instruction, may have contributed to the observed improvements in the students' memory skills. However, further research is needed to determine the long-term effects of memory training programs and to identify the most effective training methods and techniques for enhancing memory skills and academic achievement in students with learning disabilities.

Relation to prior studies

Recent studies have highlighted the potential of memory training programs in improving memory skills and academic performance in students with learning disabilities. However, the efficacy of memory training programs may depend on the specific memory strategies employed, as well as the individual needs and characteristics of each student. It is therefore crucial to develop personalized interventions tailored to the unique needs of each student.

One important consideration when developing memory training programs is the quality of the studies evaluating their effectiveness. While meta-analyses have confirmed the effectiveness of memory interventions for individuals with learning disabilities (Faramarzi et al., 2015; Peijnenborgh et al., 2016), the quality of the studies included in these meta-analyses varies. Therefore, more high-quality research is needed to further validate the effectiveness of memory interventions.

Furthermore, it is important to carefully consider the potential risks and benefits of using memory training programs for academic improvement. Some programs may be ineffective or even detrimental to learning outcomes. Therefore, it is necessary to evaluate the quality and potential risks and benefits of using memory training programs for academic improvement and to develop personalized interventions tailored to the unique needs of each student.

Recent research has highlighted the importance of individualized memory training programs tailored to the unique needs of each student (Koyama et al., 2020; Landínez-Martínez et al., 2022). This approach involves identifying specific memory deficits that may be hindering the student's learning and developing targeted strategies to address those deficits (Melby-Lervåg and Hulme, 2013). For instance, Landínez-Martínez et al. (2022) found that a personalized working memory training program significantly improved memory performance in children with ADHD. Similarly, Koyama et al. (2020) discovered that individualized cognitive training significantly improved working memory in children with developmental dyscalculia.

Recent studies have also highlighted the potential benefits of memory training programs for improving academic performance by targeting memory deficits that may hinder learning and retention of new information (Yang et al., 2017; Dunning et al., 2019; Veloso et al., 2020; Yue et al., 2023). For instance, Dunning et al. (2019) found that mindfulness-based interventions significantly improved working memory and attention in children with learning disabilities. Yue et al. (2023) discovered that a working memory training program improved working memory and academic performance in children with learning disabilities. Veloso et al. (2020) conducted a meta-analysis of memory training programs for individuals with ADHD and found that such interventions significantly improved working memory and academic performance. Additionally, Yang et al. (2017) found that a working memory training program improved working memory and reading skills in Chinese children with dyslexia.

In conclusion, memory training programs can be an effective tool for improving memory skills and academic performance in students with learning disabilities. However, it is crucial to evaluate the quality and potential risks and benefits of using memory training programs for academic improvement and to develop personalized interventions tailored to the unique needs of each student. Additionally, more high-quality research is needed to further validate the effectiveness of memory interventions for individuals with learning disabilities.

Lack of gender differences

There was no significant difference in memory test scores between male and female students with learning disabilities. This is part in agreement with a recent meta-analysis study showing that female advantage in memory processes is related to publication bias (Hirnstein et al., 2023). This is surprising because it is generally believed that males are more likely to experience learning disabilities and have stronger spatial visual abilities, while females have stronger language skills. The lack of gender difference finding is consistent with the Klein and Schwartz (1979) study that aimed to enhance the sequential auditory memory through training and its correlation with reading ability. The results of the current study indicate that the training program for memory improvement was equally effective for both male and female students with learning disabilities. The lack of significant gender differences in the memory test scores can be attributed to the fact that at the age of the students in the study, which is around 10 years old, there are no clear differences in learning abilities between males and females. Differences between males and females in cognitive abilities typically start to emerge at the end of the age of 10 or 11, with females tending to excel in linguistic ability and males in visual and spatial abilities. At around the age of 13, males tend to score higher in mathematical ability (Massan et al., 1986). This finding is consistent with the results of Klein and Schwartz (1979), which investigated the correlation between memory training and reading ability in improving sequential auditory memory. Our findings are consistent with recent studies showing lack of gender differences in memory and cognitive processes (Hirsch et al., 2019).

The lack of significant gender differences in memory test scores among students with learning disabilities is an interesting finding that deserves further exploration. While it is generally believed that males have stronger spatial visual abilities, and females have stronger language skills, recent research has challenged these gender stereotypes and highlighted the importance of individual differences in cognitive abilities (Andreano and Cahill, 2009; Reilly and Neumann, 2013).

A recent meta-analysis by Hirnstein et al. (2023) suggested that the female advantage in memory processes may be related to publication bias rather than a genuine difference in cognitive ability. This suggests that gender differences in memory performance may not be as clear-cut as previously thought and that other factors may play a role, such as cultural and environmental influences.

Furthermore, recent research has shown that the relationship between gender and cognitive abilities may vary depending on the specific cognitive domain being assessed. For example, while males tend to score higher in visual-spatial abilities, females tend to excel in verbal abilities (Voyer et al., 1995). Therefore, the lack of gender differences in memory test scores among students with learning disabilities observed in the current study may be due to the specific cognitive domain being assessed.

Additionally, it is important to consider the age of the students in the study. While gender differences in cognitive abilities may start to emerge at the end of the age of 10 or 11, with females tending to excel in linguistic ability and males in visual and spatial abilities, these differences may not be as clear-cut at younger ages (Massan et al., 1986). Therefore, the lack of gender differences in memory test scores observed in the current study may be due to the age of the participants.

The results of the current study are consistent with previous research on memory training and gender differences. For example, the study by Klein and Schwartz (1979) also found no significant gender differences in memory performance after training in sequential auditory memory. Similarly, recent studies have shown no gender differences in working memory performance (Hirsch et al., 2019) or in the effects of working memory training on cognitive performance (Abo Hamza and Helal, 2021; Abushalbaq et al., 2021; Liu et al., 2021).

In conclusion, while gender differences in cognitive abilities have been widely studied, the relationship between gender and memory performance among students with learning disabilities is not as clear-cut as previously thought. The lack of significant gender differences in memory test scores among students with learning disabilities in the current study may be due to a variety of factors, such as the specific cognitive domain being assessed and the age of the participants. Therefore, future research is needed to better understand the complex relationship between gender and cognitive abilities, especially among students with learning disabilities.

Implications

The study suggests that memory training can have a significant impact on individuals with learning difficulties, highlighting the need to include memory enhancement programs into educational practices. These programs can greatly enhance pupils' cognitive skills, resulting in improved academic achievement and increased self-assurance. The findings encourage the implementation of training in school curriculum to provide a helpful learning environment. This research paves the way for more in-depth studies on customized interventions to meet the varied requirements of students with learning difficulties, supporting an inclusive educational system that enhances achievement for all learners.

The study's conclusions reveal a necessity for educational technology and software that caters to memory training for students with learning difficulties. This may result in the creation of programs and platforms that customize learning experiences and monitor progress continuously. The study highlights the significance of teacher training in identifying and meeting the requirements of kids with learning difficulties. It supports professional development programs that provide educators with the necessary skills to utilize efficient memory training strategies. This research has the potential to impact educational policy by promoting investments in resources and training that enhance the cognitive development of all children, especially those with learning difficulties, to ensure they have equitable opportunity for academic and personal success.

Conclusions and future directions

Based on the study's findings regarding the effectiveness of the training program in enhancing memory of students with learning disabilities, the following recommendations are proposed. First, training programs should target various aspects of both developmental and academic learning disabilities, as both impact the learning process. Further, teaching techniques should be varied and individualized for educators (e.g., incorporate diverse memory strategies) in order to cater to different student groups.

Future research should investigate the correlation between memory and academic achievement, as well as the impact of enhanced memory on reading, writing, and spelling abilities of students with learning disabilities, and compare them to individuals without such disabilities. Furthermore, future research studies on academically gifted students with learning disabilities should evaluate their capacity to apply memory strategies in different educational settings.

Limitation

One limitation of the current study is the relatively small sample size of students with learning disabilities, which may limit the generalizability of the findings to a larger population. Additionally, the study did not control for potential confounding variables, such as socioeconomic status, which may have influenced the results. Furthermore, the study did not examine the long-term effects of the memory training program, which may be important for understanding the sustained effectiveness of such interventions. Finally, the study only examined memory performance and did not assess other cognitive domains that may also be important for academic success, such as attention or executive function.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Al Ain University Ethical Committee (Reference Number: AMD-16475). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

EAl: Formal analysis, Investigation, Methodology, Writing—review & editing. EAb: Conceptualization, Data curation, Writing—original draft. DB: Resources, Writing—review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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