

The Effectiveness of Augmented Reality in Teaching Arithmetic Operations to Individuals with Dyscalculia, based on the Constructivist Perspective

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ABSTRACT:

This study aimed to examine the effectiveness of a training program based on augmented reality technology using the Halo AR platform and the ADDIE model in developing mathematical operation skills among students with dyscalculia. Methodology – The study adopted a quasi-experimental design to achieve its objectives. Results – The findings revealed statistically significant improvement among the experimental group compared with the control group. Conclusions – In addition, the continuity of the program's effect was demonstrated in the follow-up measurement, proving the sustainability of augmented reality interventions. Recommendations – Based on these outcomes, it is recommended to integrate augmented reality platforms into special education curricula to enhance learning outcomes for students with learning difficulties

Keywords: Augmented Reality, Halo AR, ADDIE Model, Dyscalculia, Mathematical Skills, Special Education

1. Introduction

Arithmetic operations are considered one of the strongest indicators that predict academic achievement and future success, because a deficiency in mathematical knowledge leads to major challenges for students represented by a lack of self-efficacy and affects children's self-confidence, lack of motivation, and their phobia of mathematics, in addition to this, students are more vulnerable to developing mental health problems Castro et al., (2014). Some students also suffer from bullying from their peers, which is considered a prophecy of future failure that affects their professional and personal development (Miundy et al., 2019).

Therefore, teachers at different educational levels, especially the early stages, face different challenges in providing comprehensive educational activities in mathematics to meet the needs of students, which are represented in providing educational experiences for all students, including students with dyscalculia Lander l et al., (2009).

In addition to the stagnation in the mathematics curricula offered to students, which do not take into account people with dyscalculia. Teaching and assessment activities are another challenge for students in light of the focus on abstract information in teaching. Since the use of traditional learning methods does not provide sufficient support for these students to overcome these difficulties and enhance the emotional aspects of

learning, such as motivation and engagement (Kellems, Cacciatore, & Osborne, 2019 (Calabuig-Moreno et al., 2020; Morris et al., 2023; Reid et al., 2013; Vakaliuk et al., 2020).

Scientific studies have indicated that digital technology has positive effects on the dyscalculia of students who suffer from dyscalculia, as it improves students' understanding and increases their degree of perception of abstract mathematical concepts, enhances their self-confidence, self-efficacy and interest, and fuels their passion for mathematics (Cetintav and Yilmaz (2023) Alghamdi and Alshahrani (2025) Boonon and Sangsawang (2024) Frau et al (2025) Debnath, T. (2021) Lazo-Amado et al., (2022) One such technology is augmented reality (AR), which allows learners to interact with objects in virtual space (Miundy et al., 2019). Augmented reality provides interactive and engaging learning experiences and enhances motivation and enjoyment in learning mathematics. To confront these challenges, modern technological and digital developments were resorted to, including augmented reality programs that provide significant solutions for students in various educational fields in general and for people with dyscalculia in particular to adapt to the classroom environment. Augmented reality can be used as a cognitive tool that places the learner in a realistic physical and social context. The current study explores the enhanced effect of websites in providing support to people with dyscalculia with mathematical operations based on constructivist theory

Theoretical background.

Dyscalculia is considered one of the specific mathematical dyscalculia that refer to difficulties in understanding numbers and mathematical terms (14), according to the statistical and diagnostic guide issued by the American Psychiatric Association. (2013) Dyscalculia is a neurodevelopmental disorder accompanied by a specific learning difficulty in mathematics. Children with dyscalculia have impairments in processing numerical information, learning arithmetic facts, and impairments in their arithmetic and reasoning abilities. These disabilities are less than expected for the individual's age,

intelligence, and level of education, and occur to the exclusion of other sensory disabilities, psychological or neurological disorders, or language differences. American Psychiatric Association. (2013) The diagnostic criteria also focused on the fact that these difficulties must persist for at least six months despite the provision of appropriate educational interventions, and that the level of performance must be significantly lower than expected for the chronological age, which negatively affects academic achievement or job performance. According to Cowan and Powell (2014), difficulty learning mathematics is synonymous with dyscalculia American Psychiatric Association. (2013). Dyscalculia is a disorder that occurs in the understanding, learning, and performance of subjects that include mathematical numbers. It also affects reading and writing, in addition to attention deficit and visual problems [1]. Between 5% and 8% of children in schools around the world suffer from dyscalculia [2]

Scientific research and studies focusing on dyscalculia are relatively few compared to other dyscalculia such as reading and writing (Frau, V., Leiva, G., & Eriksson, E. (2025). A review of the scientific literature indicates that dyslexia is discussed in academic journals at a rate approximately 14 times higher than dyscalculia, (Isabelle Rapin. 2016) This disparity highlights the need for more research focusing on dyscalculia [30]. This difference highlights the need for knowledge and greater focus on dyscalculia. (Frau, V., Leiva, G., & Eriksson, E. (2025)

Augmented reality.

Digital technology is an integral part of the education system and has become more integrated into society (Cipresso et al 2018), and is an important technology in most areas of life. Augmented reality has been a pioneering technology and system in most fields, including education (Şimşek, 2024:Cipresso et al 2018,) points out that augmented reality is an emerging technology in which virtual objects are connected to the real world in real time during the user experience Augmented reality technology blends the physical and digital worlds, providing

information about the environment through images, videos, and audio on mobile devices (Kellems, Cacciatore, & Osborne, 2019). Augmented reality is defined as a visual display enhanced for real images by adding virtual elements such as text, images, sound, animation, videos, and 3D models (Sirakaya & Kakma, 2018). It is also defined as an improved representation of the real environment by adding computer-generated virtual elements (Comporos, 2024; Alghamdi, J., & Alshahrani, H 2025)..

Augmented reality (AR) could revolutionize the education system for students with dyscalculia. It provides individualized learning experiences tailored to each student's needs, simplifies complex topics, and enhances learning through different senses. Which involves interaction with 3D models and is integrated with real-world context, making learning accessible to dyscalculia students who struggle with learning from abstract ideas., (Boonon, & Sangsawang, 2024) Augmented reality also turns educational content into engaging content and fun games. Which makes educational information accessible to dyscalculia students, in addition to helping reduce stress and psychological anxiety and increasing motivation to learn.

Despite the promising possibilities of augmented reality, Frau et al. (2025) raises critical ethical concerns in its use of the effects of long training sessions of motion sickness and fatigue (mental and physical). Symptoms such as nausea, dizziness, and fatigue are caused by factors such as sensory variations between real and virtual movements, response time, graphics quality, and individual sensitivity, but we recognize the need for further research to understand these effects on students (Frau et al., 2025).

Constructivism .

One of the biggest challenges facing educational systems is that teachers cannot simply transfer knowledge to students; students need to build knowledge themselves. That is, they discover and develop information, compare new information with old information, and review rules when they are no longer valid. This constructivist perspective

on learning views the learner as an active actor in the process of acquiring knowledge. Şahin, M. points out. C. (2025) Constructivism is embodied in many ways, and these different views share important points of overlap, but also include fundamental differences. Constructivism is a method of teaching and learning based on the premise that (learning) is the product of a "mental construct." In other words, students learn by relating new information to what they already know. Constructivists believe that learning is influenced by the context in which the idea is taught, as well as by students' beliefs and attitudes. The theory suggests that humans construct knowledge and meaning through their experiences. Piaget's theory of constructivist learning has had a widespread influence on learning theories and teaching methods in education (Baharuddin, Rosli, & Johan, 2020),

Although the roots of constructivism are most often attributed to the work of Jean Piaget, its principles emerged much earlier. Piaget's emphasis was that knowledge construction occurs when new knowledge is absorbed and effectively integrated into existing, existing knowledge (Şahin, 2025).

Creating structured pedagogical frameworks that link augmented reality technology to the principles of cognitive constructivist learning is critical to realizing the full educational potential of augmented reality. Şahin (2025) confirmed that the effective integration of augmented reality applications within building environments enhances active learning and increases learners' engagement in knowledge construction. The field of education is constantly evolving, driven by technological advances that provide innovative ways to engage learners and enhance their understanding. Among these innovations, augmented reality (AR) has emerged as a particularly promising technology, capable of integrating digital information with the physical world, creating rich interactive experiences. The potential of augmented reality lies in its ability to bridge the gap between abstract concepts and concrete reality, making learning more contextual and engaging (Badilla -Quintana, Sepulveda-Valenzuela, & Salazar Arias, 2020). At the same

time, constructivist learning theories, which focus on learners' active knowledge construction through experience and social interaction, continue to provide a solid pedagogical foundation for effective education. Constructivism assumes that learners are not passive recipients of information, but rather active participants who build their own understanding through interaction with their environment and peers (Badilla-Quintana et al., 2020). Despite the enormous potential of augmented reality in education, there remains a gap in how to successfully integrate technology with cognitive constructivist theory to improve learning outcomes.

Literature Review

Recent studies highlight the growing interest in augmented reality in mathematics education. The Cetintav and Yilmaz study (2023), which examined the impact of augmented reality applications in teaching the engineering unit of the mathematics course, indicated academic achievement, self-learning skills, and motivation of secondary school students. The results showed that the application of augmented reality is fun and attractive to students, and positively affects their academic achievement and effective participation in the lesson. The Alghamdi and Alshahrani (2025) study explored the impact of integrating augmented reality into mathematics education, motivating students, and improving their academic achievement in children with learning disabilities, with a focus on subtraction skills. The results showed an improvement in learners' motivation, and both groups showed a significant improvement in subtraction skills. The Boonon and Sangsawang study (2024) also showed that augmented reality game activities in mathematics, including adding and subtracting numbers up to one hundred thousand for students with dyscalculia, achieved distinctive results in addition to an increase in the level of student satisfaction with augmented reality game activities. Frau et al (2025) explored techniques for designing three initial augmented reality applications that support students with dyscalculia (grades 1–9), while Debnath, T. noted. (2021) Augmented reality improved students' computational performance

with a significant decrease in average problem-solving time. Lazo-Amado et al. (2022) developed a mobile prototype using augmented reality technology, designed for children with dyscalculia in primary school. Includes the Miro mobile prototype app, TinkerCad 3D design software, and the Augmented Class augmented reality display app. The application was effective for students. And in the study of Miundy et al., (2019) which focused on the application of image-based augmented reality learning for people with dyscalculia. The results showed that augmented reality helps students who face difficulties in memory, abstraction, sequence processing, and motor and visual perception. Polydoros & Antoniou, (2025) found the great potential of augmented reality in supporting people with dyscalculia.

Study of the problem.

Basic mathematical and arithmetic skills are essential for various aspects of daily life and a wide range of professional fields. Mathematics enhances critical thinking and problem-solving skills, which are vital skills for decision-making and logical analysis. They are also critical to work in STEM fields, and play an important role in economics and finance.

Unfortunately, many children fall behind in school due to mathematics dyscalculia, such as dyscalculia, which greatly hinders children's ability to grasp mathematical concepts. Dyscalculia still receives much less research attention than other areas such as reading difficulties. Frau, V., Leiva, G., & Eriksson, E. (2025).

Therefore, it was necessary to search for promising solutions to create an ideal educational environment for people with dyscalculia. Augmented reality technology has emerged as an ideal solution in education, as augmented reality helps create an exciting learning environment, increases student participation, and allows for better retention of materials for them. It helps them obtain new information more effectively. This research examines the effects of combining real and virtual elements on the learning processes of

students with specific dyscalculia. The results showed that the increase successfully aided reality technology in the learning of experienced students (Kellems, Cacciato, & Osborne, 2019).

Many researchers (Şahin, 2025; Baharuddin, Rosli, & Jihan, 2020) have pointed out that developing a stimulating, meaningful, and productive learning experience requires more than just a new tool or product; integrating principles and processes, based on research-proven theories, is critical to achieving successful learning outcomes. Therefore, the aim of this research was to develop a theory-based experimental framework, based on principles extracted from more successful projects, that educational practitioners, students and systems designers can use to avoid unexpected problems during learning processes, and ensure positive results are achieved with the help of augmented reality in learning.

This was the most important research gap in previous studies. According to the researcher's knowledge, there is a scarcity of scientific studies that explore the effectiveness of educational techniques with people with dyscalculia in general and people with dyscalculia in particular, based on a scientifically proven theory such as the constructivist perspective. In addition, previous studies, as we mentioned above, do not focus on dyscalculia at the same pace as other academic difficulties. Let us not forget the need of teachers with

dyscalculia and educational practitioners for technologies that facilitate the creation of an interactive environment that facilitates the transformation of abstract computational processes and ideas into realistic sensory processes.

Therefore, this study seeks to explore the impact of augmented reality in enhancing the learning of students with dyscalculia in mathematics. The study aims to answer the following two questions:

1. Are there statistically significant differences at the significance level ($\alpha \leq 0.05$) between the average scores of the control and experimental study groups on the post-intervention dyscalculia

test, attributable to the augmented reality program versus the traditional teaching method?

2. Are there statistically significant differences at the significance level ($\alpha \leq 0.05$) between the average scores of students with learning disabilities on the dyscalculia test during post-assessment and follow-up, attributable to the augmented reality program versus the traditional teaching method?

2. Methodology

Design: The researcher used the quasi-experimental approach to answer the study questions, as a program aimed at identifying the effectiveness of a training program based on the use of augmented reality technology in improving the mathematical operations of people with dyscalculia. The variables of this study include the training program based on augmented reality technology as an independent variable and improving the mathematical operations (addition and subtraction) of people with dyscalculia as a dependent variable.

Participants/Sample: The psychometric properties (validity and reliability) of the test used in the current study, as well as the discrimination coefficients of the test items, were confirmed by applying it to a survey sample consisting of (20) students diagnosed with dyscalculia who were randomly selected from the study population and the test was applied to them.

The basic study sample to which the test was applied included (40) students diagnosed with dyscalculia who were receiving their education in resource rooms, aged between 8 and 11 years. In government schools affiliated with the First Irbid Education Directorate in Jordan, they were purposefully selected in accordance with the recommendations of the school's supporting teachers from two different schools in the directorate after obtaining approval to implement the program from the College of Educational Sciences at Ajloun National University and from the students' parents. According to the following criteria: Basic school students, second grade level. They were divided into two groups: the experimental group, which included (20) students

taught in the augmented reality program, and the other control group, which included (20) students

taught in the traditional way. Table No. (1) shows the characteristics of the participant.

Table1
illustrates the demographic and descriptive characteristics of the participants

Group	Male	Female	Total
AR	10	10	20
Control	10	10	20
Total	20	20	40

To verify the equivalence of the groups, the Mann–Whitney test (Mann–Whitney U) was used to detect the significance of the differences between the grades of students with dyscalculia in

mathematics in the pre-measurement in the experimental and control groups, and Table (2) shows this.

Table 2
Results of the Mann–Whitney U Test for Differences Between the Experimental and Control Groups on the Pretest of dyscalculia test

Group	N	Mean Rank	Sum of Ranks	Mean	U	Z	P
Experimental	20	20.75	415	9.05	195	-0.137	0.891
Control	20	20.25	405	8.85			

Table (2) shows that there were no statistically significant differences at the significance level ($\alpha = 0.05$) between the averages of the ranks of the experimental and control groups in the dyscalculia test in the pre-measurement, where the value ($Z = -0.137$) and the significance level (0.891) amounted to, which is a value that is not statistically significant. This result indicates that the two groups were equal before the program was implemented.

Instruments: First: Constructivist Augmented Reality Program for Addition and Subtraction (CARAS)

An augmented reality application was developed to support students with dyscalculia with the aim of developing their arithmetic operations represented by the skills (addition and subtraction) for the second grade level of primary school. Based on the constructivist perspective. Using the (Halo AR) platform. Based on the (ADDIE model)) The reason for choosing the model was because it

provides a systematic and organized workflow, which makes it very suitable for developing educational products - whether media, modules or educational tools - which requires a process of continuous verification and improvement and consists of stages (analysis, design, development, implementation and evaluation.) Based on the quasi-experimental approach, an experimental group and a control group were compared using a pre- and post-test. To measure arithmetic operations represented by addition and subtraction skills.

The analysis phase included identifying the necessary needs of students with dyscalculia by conducting an electronic survey of support teachers in learning resource rooms and educational technology experts. Which focused on two aspects: the educational aspect related to content, where educational objectives were determined using Bloom's theory of learning, which includes knowledge, memory,

understanding, and application of knowledge. The other aspect was the technical aspect, which focused on the availability of educational materials and means, the readiness of learning resource rooms, and the characteristics of the augmented reality program application in terms of clarity of the user interface, ease of use of navigation and sound buttons, and speed and accuracy of response

In the second phase, the augmented reality program was designed to match the characteristics of students with dyscalculia. After determining the initial requirements for the program, 3D models, interactive components, and virtual educational materials were designed, which include the presence of boxes for various balls and cards and the appearance of colorful flying objects (balloons) containing multiple balls to increase students' motivation to learn

The development phase was design-based, with an augmented reality-based learning model transformed into a product ready for testing by experts.

In the implementation phase, the program was presented to support teachers after they were trained to apply it to students with dyscalculia. It was initially tested on a group of students from outside the study sample to try to avoid design errors, and then the support teachers participated in the intervention. Prior to initiating the intervention, this research project was approved by the Ethics Committee for Research Involving Human Subjects at Ajloun National University No.: (K.A.T/125/1/221) , Dated 18 February 2026, After obtaining official approvals for the intervention, the implementation of the augmented reality program began on the experimental group, where experiments were conducted in the first semester of the year 2025/2026 to improve the addition and subtraction skills of dyscalculia students. In parallel, the students of the control group were receiving their education using the traditional teaching method. They study the same arithmetic skills as the students in the experimental group.

The intervention lasted for six weeks, with three sessions per week, each lasting approximately 40 minutes. Teachers began to intervene by presenting the program objectives and providing feedback after each session.

The final stage is evaluation by obtaining the results of pre- and post-tests. Pre-tests determined students' abilities before using the application, while post-test results showed an improvement in students' abilities after the application. Students' retention of arithmetic operations was also evaluated by re-applying the arithmetic skills test to students approximately three weeks after the post-test.

Second: Computational skills test:

The test aims to measure the arithmetic operations represented by the addition and subtraction skills required to be completed by second-grade primary school students, as included in the mathematics book and teacher's guide approved by the Ministry of Education in Jordan. The results of the electronic survey of supporting teachers showed that there was difficulty in this. These skills are (addition skills, mentally adding multiples of ten and one hundred, mental addition, addition with regrouping, estimating the result of addition (2,1), addition properties, subtraction skill, mentally subtracting multiples of ten, mental subtraction, subtraction with regrouping, subtraction with zeros, estimating the result of subtraction)

The validity of the test was calculated by the apparent validity, as the test was presented to a number of judges, including professors specializing in special education, educational psychology, measurement, and evaluation (10), to verify the apparent validity of the test by expressing their opinion, adding and modifying the test according to their observations, and the extent of its connection to the measurement for which it was developed. The arbitration resulted in the arbitrators agreeing by a percentage of (80%) on the clarity of the issues, their relevance to the topic and the ease of answering them. They also agreed on the dimensions of the test and the number of its paragraphs, which consisted of 28 paragraphs. They did not delete any paragraph. According to

their comments, the format of the general form of the test was modified, such as changing the font size of the paragraphs to suit the students' mathematical difficulties.

The responses of a survey sample from outside the study sample, consisting of (20) students, were also analyzed to calculate the difficulty and discrimination coefficients for the test items using the (SPSS) program. The percentage of students who answered the paragraph incorrectly was adopted as a difficulty coefficient for each paragraph of the test, while the discrimination coefficient for each paragraph was calculated through Spearman's correlation coefficient between the paragraph score and the total score of the test. Table (3) shows the difficulty coefficients and discrimination coefficients for each paragraph of the test.

Table 3

Item Difficulty and Discrimination Indices

Item No.	Difficulty Index	Discrimination Index
1	0.45	0.54*
2	0.65	0.69**
3	0.60	0.57**
4	0.45	0.70**
5	0.50	0.76**
6	0.45	0.49*
7	0.60	0.57**
8	0.60	0.62**
9	0.60	0.51*
10	0.55	0.57**
11	0.45	0.68**
12	0.60	0.61**
13	0.60	0.56*
14	0.70	0.62**
15	0.50	0.76**
16	0.65	0.65**
17	0.70	0.64**
18	0.60	0.48*

19	0.65	0.52*
20	0.70	0.64**
21	0.50	0.47*
22	0.55	0.49*
23	0.55	0.64**
24	0.50	0.57**
25	0.60	0.51*
26	0.70	0.74**
27	0.60	0.46*
28	0.70	0.68**

* Statistically significant at the 0.05 level

** Statistically significant at the 0.01 level

It is noted from the table that the paragraph difficulty coefficients ranged between (0.45–0.70), while the discrimination coefficients ranged between (0.46–0.76). Based on what Awda (2010) indicated regarding the acceptable range of paragraph difficulty, which ranges between (0.20–0.80), all paragraphs are considered within the acceptable range. The discrimination factor is also considered appropriate if it is higher than (0.39), acceptable and recommended for improvement if it ranges between (0.20–0.39), and weak if it ranges between (0.00–0.19), while paragraphs with negative discrimination are deleted. Accordingly, none of the test items were deleted, either based on the difficulty factor or the discrimination factor.

Third: Stability of test scores for arithmetic skills:

To ensure the stability of the test, the test-retest method (test-retest) was verified by applying the test and re-applying it after two weeks to a group outside the study sample consisting of (20) students. Then, the Spearman correlation coefficient was calculated between their estimates both times, as it reached (0.90) for the test as a whole.

The stability coefficient was also calculated using the internal consistency method according to the Coder-Richardson equation -20, as it reached (0.93) for the test as a whole, and these values were considered appropriate for the objectives of this study.

Test Description Computational Skills:

The arithmetic operations test was built to measure students' academic achievement in the addition and subtraction units. It included two dimensions: addition and subtraction, based on the constructivist perspective, which came in 28 multiple-choice questions within a table of specifications on the addition and subtraction dimensions, so that it covered the basic skills in the addition dimension, which are (addition of multiples of ten and one hundred, mental addition, addition with and without regrouping, addition properties, estimating the result) and covered the basic skills in the subtraction dimension (subtraction of multiples of ten and one hundred, mental subtraction, Subtraction with and without regrouping, subtraction with zeros, and estimating the result of subtraction) The paragraphs were distributed into three cognitive levels according to constructivist theory, which are: the level of memory, the level of understanding, and the level of application, with the aim of measuring the students' higher cognitive processes. The number of remembrance paragraphs reached (4) paragraphs, the number of understanding paragraphs reached (13) paragraphs, and the number of application paragraphs reached (11) paragraphs Across levels of knowledge, memory and application. The results of the content analysis showed that subtraction and estimation skills need to be enhanced in the test, given that they represent common difficulty points among students with dyscalculia, which necessitated increasing their representation in the test, and the total became 28 questions, each answer being given one point. Accordingly, the test was objectively corrected by giving a score of 1 for the correct answer and 0 for the incorrect answer. The total score for the test is 28, and the test was presented to the students by a supporting teacher who played an important role in ensuring that the students understood the meaning of each question. This role involves clearly reading questions aloud, simplifying language to make it easier to understand, providing concrete examples relevant to students' daily experiences, and helping them choose answers based on their own understanding

and experiences. In this way, students can provide more accurate answers while reducing potential barriers caused by limitations in understanding language or understanding abstract concepts.

3. Results

To answer the first study question, which states, "Are there statistically significant differences at the significance level ($\alpha \leq 0.05$) between the average scores of the control and experimental study groups in a post-intervention test, attributed to the augmented reality program versus the traditional teaching method?" The Mann–Whitney (Mann–Whitney U) test was used to detect the significance of differences between dyscalculia students' scores on dimensional measurement in the experimental and control groups, and Table No. (4) shows this.

" Table 4

Results of the Mann–Whitney U Test for Differences Between the Experimental and Control Groups on the Posttest of dyscalculia test

Group	N	M	Su	M	U	Z	P	Eff
		ea	m	ea				ect
		n	of	n				Siz
		Ra	Ra					e R
		nk	nks					
Experi	2	25.	519	19.	90.	-	.0	.47
mental	0	98	.50	70	500	2.	0	
Contro	2	15.	300	16.		97	3	
l	0	03	.50	40		2		

Table (4) shows a clear superiority in the averages of the experimental group compared to the control group. The results showed that there were statistically significant differences at the significance level ($\alpha \leq 0.05$) between the averages of the ranks of the experimental and control groups in the dyscalculia test in dimensional measurement, where the value of the significance level reached (0.003), which is less than (0.05), which indicates the presence of statistically significant differences between the two groups. The results also showed that the average ranks of the experimental group were (25.98) compared to the control group, whose average ranks were

(15.03), while the arithmetic mean of the experimental group was (19.70) compared to (16.40) for the control group. These results indicate the superiority of the experimental group students who studied using the augmented reality program compared to the control group students who studied using the traditional method.

It also showed the size of the calculated effect, which amounted to ($r = 0.47$), which shows that the effect of the augmented reality program in improving the performance of students with dyscalculia is a moderate effect that tends to be large according to Cohen's criteria, which indicates that this program did not only achieve statistically significant differences, but also had a noticeable practical effect in improving students' performance.

This result can be explained in light of the effectiveness of augmented reality in improving the learning of students with dyscalculia, by providing an interactive learning environment that contributes to simplifying abstract mathematical concepts and increasing their learning motivation

The results of the second question, which states, "Are there statistically significant differences at the significance level ($\alpha \leq 0.05$) between the average scores of students with learning disabilities on the dyscalculia test during post-assessment and follow-up, attributed to the augmented reality program versus the traditional teaching method?"

The Wilcoxon Signed Rank Test (Wilcoxon Signed Ranks Test) was used to reveal the significance of the differences between the two dimensional measurements and follow-up of the grades of students with dyscalculia, and Table (5) shows this.

Table: 5

Results of the Wilcoxon Signed Ranks Test for the significance of differences between post-test and follow-up measurements

	Numb er	Mea n Ran k s	Sum of Rank s	Z	Statistical Significan ce
Negati ve	9	7.56	68.00	-1.58	.113

Ranks			4
Positiv e	4	5.75	23.00
Ranks			
Ties	7		
Total	20		

Table No. (5) shows that there were no statistically significant differences at the significance level ($\alpha \leq 0.05$) between the students' average scores in the post-measurement and the follow-up measure in the dyscalculia test, as the significance level value reached (0.113), which is greater than (0.05), indicating that there were no statistically significant differences between the two measurements. The results also showed that the number of negative ranks reached (9) with an average rank of (7.56) and a total rank of (68.00), while the number of positive ranks reached (4) with an average rank of (5.75) and a total rank of (23.00), and the number of equal ranks reached (7)

This result indicates that there was no decline in student performance between the post-measurement and the follow-up measurement, which indicates the stability of the impact of the augmented reality program and the continuity of the improvement achieved by students after the end of the program implementation, which reflects its effectiveness in creating a continuous educational impact compared to the traditional method.

4. Discussion

The first main objective of this study was to shed light on examining and exploring the effectiveness of augmented reality in teaching arithmetic operations based on constructivist theory. The results of the study showed that with the first question, which examines the effect of augmented reality intervention versus traditional teaching, the results showed that augmented reality intervention was very effective in teaching students with dyscalculia arithmetic operations. The augmented reality group excelled significantly, not only statistically, but also practically. This is consistent with what has been indicated by many scientific studies that have confirmed the effectiveness of

using augmented reality in educating people with disabilities and difficulties in general and people with dyscalculia in particular. Among these studies are Alghamdi & Alshahrani, 2025; Cetintav & Yilmaz, 2023; Boonon & Sangsawang 2024; Debnath, T. 2021; Lazo-Amado et al., 2022)

This underscores the need to work on developing educational programs that rely on modern technologies in general and augmented reality in particular. The interactive element of augmented reality allows dyscalculia learners to interact with educational materials and actively participate in the learning process, rather than simply watching without interacting with them as is the case with traditional educational materials. In addition to what augmented reality provides in terms of stimulating the student's various senses, such as the visual, auditory, and motor senses, which arouse their attention and increase their motivation, which was emphasized by constructivist theory in a way that is incomparable to the traditional methods prevailing in education.

The other main objective of this study, which was to explore the effectiveness of augmented reality in keeping learners with dyscalculia in arithmetic operations for the longest possible period, the results of the current study confirmed that there was no decline in students' performance between the post-measurement and the follow-up measurement, which indicates the stability of the effect of the augmented reality program and the continuity of the improvement achieved by students after the end of the program application. This reflects its effectiveness in creating a continuous educational impact compared to the traditional method. Augmented reality has greatly helped students retain as much of their math as possible in their long-term memory. The application strategies used had the greatest impact in attracting their attention and increasing their motivation. The repetition of information and the presentation method used by focusing on different sensory methods such as visual, auditory, interaction and avoiding abstraction transformed the mathematics subject for students from a rigid and difficult curriculum into a subject beloved by students, which contributed to enriching the

experience of learners who suffer from dyscalculia (Miundy et al., 2019). It increased students' free exploration of the virtual environment and interaction with the application without a pre-determined sequence, and practicing the application without a punishment mechanism, which spared them from falling into the frustration of repeated failure and strengthened their determination to achieve and master. Unlike students who were educated in the traditional way. This is consistent with what some researchers in this field have indicated, such as Miundy et al., 2019; Badilla-Quintana et al., 2020; Lazo-Amado et al. 2022; Frau et al 2025)

Address limitations of the study What distinguishes the current study is that the application was based on a scientifically proven constructivist research perspective, which was the strength of this study, in addition to research into calculation difficulties despite the lack of efforts focused on this category.

However, limiting this study to addition and subtraction skills in arithmetic operations and limiting it to second-grade children is considered one of the limitations of the current study.

5. Conclusion

Our current study explored the effectiveness of augmented reality intervention in improving arithmetic operations for people with dyscalculia based on constructivist theory. The results of the current study indicate the effectiveness of augmented reality intervention in learning addition and subtraction skills compared to the traditional teaching method.

In addition, the results showed the effectiveness of augmented reality teaching in retaining mathematical operations for a period extending from three weeks or more after applying the program, specifically the skills of addition and subtraction. These findings, part of a body of recent research, contribute to the effective use of modern technologies in the education and training of people with disabilities. Providing special, qualitative breeding environments.

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However, limiting this study to addition and subtraction skills in arithmetic operations and limiting it to second-grade children is considered one of the limitations of the current study.

The current study suggests conducting further studies to explore the impact of augmented reality

based on other theories such as behaviorism and cognitive load. Conducting more studies to explore the impact of augmented reality in raising the level of academic achievement of students with disabilities in general in other mathematical operations and various fields of knowledge. It also suggests conducting additional studies at educational levels other than the primary level to which this study was allocated.

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