

The Effectiveness of Augmented Reality Technology (Metaverse) on Mathematics Achievement among Students with Learning Difficulties

Somaia Al-Nawaiseh^{1*}.

¹Ministry of Education, Amman, Jordan.

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*Corresponding author:

Ministry of Education, Amman, Jordan.

Email: dr.somaia.n@gmail.com.

Abstract

The study aimed to assess the effectiveness of using augmented reality (Metaverse) technology on the academic achievement in mathematics among fifth-grade students with learning difficulties in the Southern Al-Mazar district. An experimental approach was employed, utilizing an application based on augmented reality to teach a mathematics unit, along with an achievement test to evaluate the treatment's effects. A purposive sample of 60 male and female students with learning difficulties was used. After implementing the measurement tools during the academic year 2022/2023, where validity and reliability were verified through appropriate methods, statistically significant differences were observed between the means of the control and experimental groups in favor of the post-application. Additionally, no significant differences were found in the achievement of students with learning difficulties in arithmetic due to gender. The study recommended the importance of integrating modern technology and augmented reality applications in teaching students with learning difficulties and encouraged further research in this field within Arab contexts.

Keywords: Augmented Reality (Metaverse), Learning Difficulties, Academic Achievement.

1. Introduction

Learning disabilities refer to difficulties in understanding certain forms of learning. Children who suffer from these difficulties have abilities that hide deficiencies in their performance, they may tell wonderful stories even if they are unable to write, and they may succeed in performing complex skills even though they may fail to follow simple instructions, they suffer from many difficulties in learning some skills at school, such as being unable to read or to write, and others may make frequent mistakes, and face real difficulties in learning mathematics (Al-Khatib & Al-Hadidi, 1997; Adass, 2000).

The term Learning Disabilities refers to the existence of problems in the academic and social fields compared to ordinary students, children with learning disabilities have a delay in their ability to read, write, and mathematical abilities by years, compared to their normal classmates of same age group (Vaughn, et al., 2001).

Also, many studies have found that some students with learning disabilities, show social behavioral characteristics that affect their learning, such as Aggressiveness and talkativeness, fantasy and distraction, not completing the tasks required of them, social withdrawal, rejection from peers, difficulty following instructions, not participating in dialogues, and the formation of other behavioral problems, such as a lack of social skills, adaptation in social life, and a low level of self-concept they have, compared with their normal peers (Sheri& Sharon, 2019).

Children with learning disabilities can be defined as those who show disorders in one or more of the basic psychological processes, which include understanding and using written or spoken language, which appears as a deficit in the ability to speak, think, listen, read, spell, or in arithmetic skill, which all related to various sensory disabilities (Al-Khatib and Al-Hadidi,1997).

Students with Learning difficulties have disorders in basic psychological functions such as perception, remembering, and the formation of concepts, and they may not be able to understand spatial directions, remember educational material, or the ability to write it, and they have some psychological disorders, such as anxiety, shyness, and fear. In the school, it has a clear effect on the adaptation of children with learning difficulties, especially if stimuli are provided to them to activate their role (Jouda, 2018; Khasawneh, 2014).

The causes of learning difficulties

The causes of learning difficulties refer to physiological factors, including hereditary and genetic factors, simple brain dysfunction, maturity and malnutrition, diseases, psychological factors, and environmental factors (Abu Hassouna, 2004; Brace, Iaaren & Robin, 2020), and there are two types of learning difficulties:

Developmental learning disabilities

These difficulties are related to brain functions, like mental and cognitive processes that the child needs in his academic achievement, and they are important for the development of the child's processes and skills (Khasawneh, 2014).

Academic learning difficulties

Children with learning disabilities suffer from a delay in their ability to read, write, and mathematical abilities by years from their peers of the same age, and the following are kinds of Academic learning difficulties (Awad Allah, Ashour & Al-Shehadeh, 2017; Janet & Bever, 2014):

- Dyslexia affects a person's ability to read fluently without any stuttering, as well as the ability to speak and understand.
- Dysgraphia, this type causes a defect in the process of handwriting and spelling, in addition to the ability to think and write at the same time.
- Language disorder, this type is concerned with the ability to express and form sentences.
- Auditory and visual disorders include a defect in understanding and distinguishing sounds, in addition to a defect in the perception of visual matters, and the ability to coordinate functions between the hand and the eye.

- Dyscalculia is related to mathematical operations, which affects the understanding of mathematical symbols and numbers, in addition to the ability to count and know the time. In this regard, mathematical difficulties known as dyscalculia appeared among some students with learning difficulties (Lerner, 2000).

Some of the mathematical difficulties (Zayyat, 2001; Lerner, 2000):

- Difficulty using and understanding mathematical concepts and facts.
- Difficulties in computational comprehension and numerical and mathematical reasoning.
- Difficulties in mathematical treatments.

A child is classified as having difficulties in arithmetic, if he has a high intelligence degree or normal with a deviation or divergence between the mental age and the mathematical achievement of up to two years, as the mathematical difficulties appear in most ages, starting from the pre-school stage on difficulties in dealing with geometric shapes, volumes, and relationships, and continue even after the school stage and the difficulty reaches its climax in the stage after the seventh grade (Mercer& Mercer, 2001).

There are unspecified difficulties. These difficulties include problems in concentrating, hyperactivity, and attention, which lead to difficulty in discipline and control of general behavior and may be accompanied by a defect in coordination between speech and the coherence of sentences. It also notes difficulties in brain functions related to memory, whether short or long-term, which affects memorization, storage, and retrieval of things (Al-Batayneh et al., 2015).

Many studies have dealt with teaching methods provided to students with learning difficulties, and educational technology is considered one of the modern methods that have contributed to improving the learning of students with special needs, through its various applications (Al-Khatib, 1994).

Modern technology and education.

Technological developments have a major role in the field of learning in universities and schools, teaching offers distinguished quality, which increases the ability of the learner to understand and assimilate the educational content, provides easy ways to obtain learning at the lowest costs, and ensures the continuity and quality of education, we can determine the most important advantages of smart technological applications in education in the following (Al-Sharman, 2013, Nidal, 2012; Al-Darwish, 2017):

- Supporting the education process and stimulating creativity and innovation among students.
- Can be used anywhere and anytime.
- Developing the spirit of cooperative work among students.
- Provide an interesting and motivating learning environment for work.
- Integration of the virtual environment and the real environment within the framework of learning.

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- Providing virtual applications that simulate reality, which helps to organize the mind and reach understanding.

Metaverse technology.

Metaverse technology is one of the modern technology concepts, it can be defined as linking the real world with the virtual world on the computer and taking advantage of software technology with 3D imaging to transfer learners to the virtual world (Akçayır, Akçayır & Ocak, 2016).

It is the use of all software sciences, such as animation and simulation techniques, and the use of multimedia as educational effects; In which the learner interacts while he lives in the real world with educational effects in the virtual world, and thus the augmented reality technology is to merge reality with virtual reality, synchronized with it based on visual and audio stimuli based on computer technologies to achieve meaningful learning for learners (Ivanova & Ivanova, 2012).

The mechanism of Augmented reality technology's work

Augmented reality technology consists of three aspects represented in a group of real and virtual shapes in a coordinated position, and a group of people interacting with virtual shapes while they live in the real world, in addition to the link between real and virtual shapes (Akçayır, Akçayır & Ocak, 2016; Akl (2014) also, indicated that the components of augmented reality technology depend on digital educational objects that can be obtained via the Internet, which made them simple in production and costs.

Al-Maalawi (2016) adds that augmented reality technology helped to access a lot of information by simply shining the camera of the smart devices on the paper book, which facilitates the education process and creates fun in the educational environment, and makes it more effective, and the information is visually perceived more clearly and quickly, more than reading it from a paper book.

Yoon, Anderson & Elinich (2017) showed that augmented reality technology allowed learners to know the unseen things in explaining the theories of pressure and airflow, which are among the difficult aspects of Bernoulli's theory, and allowed them to understand complex relationships between the different variables.

Metaverse Augmented reality technology in education

Metaverse augmented reality application is considered one of the modern applications, that contribute to the field of education, it can be defined as the technology that combines virtual reality with real reality so that virtual reality appears as a real reality (Al-Mashrani, 2018). Augmented reality applications appeared in the fifties of this century, then the applications developed by adding digital elements and expanding scenes, settings, and features.

Abdullah, Kansara & Ihsan (2015) defined it as converting reality in the real world into digital data, assembling and imaging it using digital display methods that reflect the real reality of the environment surrounding the digital object, they considered it to be an expansion of real reality by adding layers of computer-generated information to the real environment, and this added information can be text, graphics, video, audio or GPS.

The application of augmented reality has entered the field of education, and although it is widespread in some countries, its effects are evident in other countries. The educational environment is a fertile environment for the application of augmented reality technology, as it can be used to convert paper books into interactive display platforms via smart devices. Instead of reading the history of the pyramids, for example, a three-dimensional paranoiac cartoon character can be made that tells the story of the pyramids and shows to live video recordings by simply pointing the smart device's camera toward the book. Or it may be used in human anatomy lessons, by seeing the organs in a three-dimensional image, which facilitates explanation for the teacher and helps the student for a deeper understanding of the lesson.

Advantages of AR (Metaverse).

The advantages of augmented reality AR (Metaverse) in education can be summarized as follows (Azuma, Billot, Feiner, Behringer, Julier & MacIntyre (2001) and (Liarokapis, Anderson, 2010):

- Mixes reality and the virtual world in a real environment.
- Interactive at the time of use.
- Provide clear, robust, and accurate information.
- The possibility of entering information easily and effectively.
- The possibility of interaction between the two parties, such as the teacher and the learner.
- Make complex procedures easy for users.
- Cost-effective and easily expandable.
- Presenting the models simply and clearly to the learners within the educational situation plan.
- The cost of producing educational materials is relatively low.
- The educational situation gives a lot of dynamism and activity.
- It combines the explanation of the actual teacher and the digital object.

Learning with Augmented reality for students with learning disabilities

In the field of teaching students with learning difficulties, there is a great importance of augmented reality applications stimulates motivation and provide rich, attractive, and interesting content that may reduce distraction for some students, and provide opportunities for students to engage in work, with consideration of individual differences, different abilities, and so on. The biggest difference between virtual reality and augmented reality is that virtual reality takes the real, realistic object (human) to a virtual world, while augmented reality brings the virtual object (virtual objects) to a realistic world (Ibrahim, 2013; Jouda, 2018).

Challenges of Augmented Reality in education

Despite the great benefits of augmented reality in education, it still faces some obstacles as the following (Yuen, Yaoyuneyong & Johnson, 2011; Catenazz & Sommaruga, 2013):

- Lack of necessary training, as there is a great shortage of people ready to work on these techniques.
- Hardware and requirements, the use of augmented reality in education require many tools and devices, from the institution or on the part of the students, which are still not available to many now.
- Problems with the ability to transfer content, it is currently difficult to provide the same quality of augmented reality content on any device, and in general, not all devices are properly required for everyone.

Some previous studies have been conducted about using modern technology, including augmented reality in education in general, and some studies focused on the category of students with learning difficulties.

The aim of study by Ahmed (2020) is to identify the effectiveness of using augmented reality technology on chemistry learning difficulties, and to develop motivation for achievement among high school students. The research was applied to a sample of first-year secondary students in school in Cairo. The research tools were the student's book, the teacher's guide, the chemistry learning difficulties test, and the achievement motivation test. The research concluded with several results, the most important of which is that the students of the experimental group outperformed the control group in the chemistry learning difficulties test. The results also indicated the treatment of many chemistry learning difficulties related to chemical concepts and solving chemical problems.

Jouda's study (2018) aimed to reveal the effectiveness of using augmented reality in developing mathematical problem-solving skills, and emotional intelligence among primary school students with difficulties in learning mathematics. A sample of 30 students were used, and the study tools were prepared and included a test for solving mathematical problems and the emotional intelligence scale. The study concluded the following: the effectiveness of using augmented reality in developing mathematical problem-solving skills for primary-stage students with difficulties in learning mathematics, and the effectiveness of using augmented reality in developing emotional intelligence among primary school students with difficulties in learning mathematics.

Akl and Azzam (2017) studied the effectiveness of employing augmented reality technology to develop seventh grade students in chemistry at Gaza Strip, using elements 4D. The researchers used the quasi-experimental approach, research sample was (93) students from the seventh-grade students. The research tool was an achievement test. The test was applied to both groups (experimental/control). The experimental group studied using augmented reality technique. The control group studied using traditional methods. The results showed that there were significant differences between the average control and experimental group in the post-test favor for the

experimental group, also the augmented reality technology achieved a high efficiency, and raised the level of students in chemistry subjects.

The study by (Tacgin, Ulucay & Ozuag, 2016) purposed to reveal the impact of using augmented reality in education on some skills among students, they use computer programs depended on AR, the result showed the use of augmented reality technology led to an increase in learners' skills, related to cooperation and social communication and increased motivation to learn.

The aim of study by (Gopalan, Abdul nasir & juliana, 2016) is to determine whether the intervention of the enhanced science textbook using augmented reality contributes to the learning process of lower secondary school students in science. The study was carried out among a sample of 70 lower secondary school students. Pearson Correlation and Regression analyses were used to determine the effects of ease of use, engaging, enjoyment and fun on students' motivation in using the augmented reality science textbook for science learning. The results provide empirical support for the positive and statistically significant relationship between engaging, enjoyment and fun and students' motivation for science learning. However, Ease of use is not significant but positively correlated to Motivation.

The purpose of the study (Chen& Liao, 2015) was to investigate the effects of types of augmented reality and guiding strategy on senior high school students' performance and motivation of electrochemistry concepts. The participants were 152 freshmen of senior high school. A 2X2 quasi-experimental design was employed. Dynamic-AR) and type of guiding strategy (procedure-guided vs. Question-guided). Two types of augmented reality were employed, and two types of guiding strategies were cooperated, including procedure-guided strategy and question-guided strategy. The results revealed that the procedural guidance group achieved better learning application performance than the question guidance group, and the static augmented reality group outperformed the dynamic augmented reality group, and the procedural guidance group outperformed the question guidance group also, students showed positive motivation toward learning Chemistry no matter which augmented reality type they used, especially students who used the static augmented reality revealed higher motivation than those who used the dynamic augmented reality.

A study by (Chen, 2013) aimed to examine the effect of augmented reality technology in facilitating the learning of chemistry in a collaborative manner, where 90 students were divided into three groups, a group that studied through books only, a group through augmented reality only, and a group in the form of Collaborative pairs and augmented reality, the results showed that the performance of the group of learners who studied using augmented reality was much better than the learners who studied by themselves without using augmented reality, while the learners who studied with augmented reality in cooperative pairs had better results than the previous two groups, and this indicates the role that Augmented reality technology plays a role in learning.

In study by (Abu Hawash, 2008) aims to uncover the effect of using educational technology on the academic achievement of students with learning difficulties in fourth grade primary school mathematics and their motivation towards learning it in Doha, State of Qatar. The study population consists of all students with learning difficulties in academic year 2019/2020, where the study sample consists of (60) students with learning difficulties in Doha, who are randomly selected,

where the study tool is used, which is a test achievement consisting of (40) items, and a measure of motivation towards learning mathematics is used, as the results of the study indicated that there are statistically significant differences in the level of motivation towards learning mathematics. The study recommends adopting the use of educational technology in teaching and designing curricula, working on and including it in the next plan for the general education stages, and providing the material capabilities and appropriate conditions in educational environments to apply this type of learning.

The current study similar with a number of previous studies in terms of searching a significant effect of using augmented reality technology in education in general, like these studies (Chen & Liao, 2015), (Akel& Azzam, 2017), (Jouda's, 2018) and (Ahmed, 2020), and this study benefited from the references, tools and AR programs used in some previous studies like: (Akel, 2014), (Ibrahim, 2013), (Jouda, 2018), (Dulaimi, 2020), and (Gopalan, Abdul nasir& Juliana, 2016).

And it differs from many previous studies in selecting the study sample of students with learning difficulties, in the basic learning-stage, and it also differed in choosing a unit of mathematics and applying an augmented reality program to clarify abstract concept, and knowledge of modern mathematics books in Jordan, which were developed and built to suit normal students without learning difficulties, so young students with learning difficulties suffer from difficulties in understanding and assimilating many of the concepts especially dyscalculia and need a new strategy to help them.

2. Study Problem and Questions

Students with learning disabilities face many challenges during their learning because they suffer from dyslexia in reading, writing, arithmetic, and perception, which affects their understanding of science, mathematics, and culture subjects. And the presence of many abstract concepts in the new different curricula makes it difficult for students to learn easily, most abstract concepts, especially in math, seem more complex and there are many connections between their different parts, in addition, they are tangible present for learners (Khasawneh, 2014).

Understanding and realizing abstract concepts is based on the learner's ability to imagine those connections and understand the educational content that revolves around them. There is a need to search for educational methods that achieve the goals of learning, as this study, in which augmented reality technology is used, to help learners to embody those abstract concepts that abound in mathematics and arithmetic subjects, to reduce the cognitive burden of learners to achieve a higher level of achievement. Also, widespread digital learning tools encourage learners to generate knowledge through modern technologies provide, like employing augmented reality technology in the educational process.

Because research problem was determined by researcher follow-ups and observations as an educational supervisor, there is a low achievement of students with learning difficulties in the basic stage, that they have a weakness in understanding many abstract concepts of mathematics, and they find it hard to understand relationships, and dealing with numbers and operations on them, there may be a need to search for new strategies to help them understand mathematics well, and

because augmented reality applications are distinguished by their inclusion of images, videos, and other learning aids, I chose it as a learning strategy to research its effectiveness.

And the scarcity of studies that examined the application of augmented reality in the education of students with learning disabilities in Arab environments, I was encouraged to do this study.

2.1 Study questions.

The current study aims at examining the effectiveness of using augmented reality applications in mathematics academic achievement for students with learning disabilities. The study attempts the following questions:

1. Is there effectiveness when using augmented reality applications in mathematics academic achievement for students with learning disabilities?
2. Is there effectiveness when using augmented reality applications in mathematics academic achievement for students with learning disabilities due to gender variable?

3. Significance of the Study

The importance of this study stems from theoretical and practical significance, theoretically it is detecting the effectiveness of using augmented reality applications in improving the achievement of students with learning difficulties in mathematics and arithmetic, It contributed to providing learning methods in teaching students with learning difficulties, especially in the absence of sensory, as pictures and videos which can be added to traditional abstract learning. It also opens horizons for researchers in other sciences to use this technology in a way that suits the educational situation, and to enrich the library of experimental research in the science of educational techniques and methods of teaching students with learning difficulties for other topics, especially in Arab libraries.

The practical importance of the study is in increasing the motivation of students with learning disabilities towards learning in the field of mathematics and other subjects, after breaking the barrier of fear of using modern technology, as they will be able to search for applications and benefit from them also, teachers can add learning by using augmented reality applications, to modern active learning strategies, used in student learning, as the research is a result of modern trends in learning that call for technical learning to be combined with traditional learning.

4. Procedural definitions

The research terms can be defined as follows:

Augmented Reality

A pattern of mobile learning through smart devices, by merging virtual reality with real reality in two or three dimensions, in a way that achieves interaction in the learning process and creates a learning environment based on active interaction with the content provided, at a speed that suits the learner's circumstances (Ahmed, 2020; Al-Ghamdi, 2015).

Learning Difficulties

obstacles that hinder learning, which cause a low level of understanding among the student and a decrease in his academic achievement, with an emphasis on the fact that this category of students does not have any kind of physical, visual, or sensory disabilities, and are not mentally handicapped (Al-Khatib & Al-Hadidi, 1997; Al-Batayneh et al., 2015).

Academic achievement

Academic outcomes that indicate the extent to which a student has achieved their learning goals, academic achievement is often measured through examinations or continuous assessments (Dulaimi, 2020), and in this study, the academic achievement of students was measured through their responses to the achievement scale used in the study.

5. Limitations of the study

The limits of the study:

- Spatial limitations: determine the spatial framework of research in the schools of the southern Al-Mazar district of the Jordanian Ministry of Education.
- Time limits: the time limits were related to the study period from 2020 until 2023.
- Human limits: the research and its results are determined by the sample of the study, in which the study tools were applied, and they are samples which were chosen randomly, from school in Al-Mazar Al-janobi district.

6. Method

6.1 Study hypotheses

In this study, the researcher sought to test the validity of the following hypotheses:

- There are no statistically significant differences at the level ($\alpha < 0.05$) between the mean scores of the control and experimental groups, on achievement test of the fifth-grade students with learning disabilities, in Mutah Basic Mixed School, due to the teaching method.
- There are no statistically significant differences at the level ($\alpha < 0.05$) between the mean scores of the control and experimental groups on achievement test of the fifth-grade students with learning disabilities, in Mutah Basic Mixed School in favor of teaching with augmented reality, due to the gender variable.

6.2 Participants.

It includes all students with learning difficulties in the elementary schools of the southern educational district in Al-Mazar Al-janobi, for the year 2022/2023 AD, whose number is approximately (940) students, distributed to (47) basic schools.

The sample of the study consisted of (40) male and female students with learning difficulties, from basic schools in the southern Mazar district, who were purposive chosen from the fifth-grade students, from the Mutah Mixed Basic School, in the academic year 2022/2023 AD,

They were chosen purposively, because the selected school has an internet services and a computer lab, in which augmented reality technology can be applied, and the students in experimental group have smart mobiles, also its easy for researcher to be in the school at any time during the work.

20 students were allocated as a control group and 20 for the experimental group, Table (1) shows the distribution of the sample.

Table (1): Distribution of the sample

Group	Male	Female	Total
Control	10	10	20
Experimental	10	10	20
Total summation	20	20	40

6.3 Study approach

The experimental approach was used in two groups (control and experimental), where an achievement test for a math unit was applied to the two groups, as a pre-test to measure the cognitive skills, then the treatment was done by teaching the unit to the experimental group only, with augmented reality, and teaching the control group in the usual way, then doing a post achievement test to measure the cognitive skills in the unit Math's. To investigate the effectiveness of using augmented reality in raising the academic achievement of Students with learning difficulties in mathematics. Table (2) shows the research methodology.

Table (2): Study Methodology

Study groups	Pre-test	Teaching methods	post- test
CG	O	X1	O
EG	O	X2	O

CG: Control group

EG: Experimental group

O: The test

X1: Teaching with augmented reality.

X2: Traditional teaching.

6.4 Study Instruments

The study tools can be described as follows:

First: achievement test

After reviewing the previous literature related to activating the applications of augmented reality in teaching and the impact of technology on raising the achievement of students, especially those with special needs (Al-Maalawi, 2016; Adass, 2000; Al-Ghamdi, 2018) , an achievement test has been prepared for some mathematics lessons, and it was given to the control and experimental once before treatment and once after treatment.

The achievement test consists of four questions, the first question contains a table that includes four shapes, and the student has to determine if it is a polygon or not, and if it is a polygon, he determines whether it is regular or not, and the second question related to triangles, he is given 6 triangles And he should color the equilateral triangles red, and the isosceles triangles yellow, or leave them uncolored if they were not equilateral or isosceles, the third question is about the angles of triangles, he was given 4 triangles and he should classify them according to the angle's measurement, then the question 4 asked him to draw the quadrilateral according to the description given about (4 shapes), then he should classify the type of quadrilateral they are given in the fifth question. Quartet marks are distributed according to the results of the test specifications table, and the total score for the test is 25 marks.

The steps for building the test were as follows:

- Determine the lessons to be taught, which are the lessons of the geometry unit in the fifth-grade book, the Jordanian curriculum for the year 2022/2023 AD, and the lessons include (polygons, triangles, classification of triangles, quadrilaterals, and their classification.
- The results of these lessons have been reviewed.
- Lesson content analysis.
- Building a table of specifications for the questions according to the special outcomes of the lessons and determining the marks as in Table (3).
- Prepare test papers with correct answers.

Table (3): Content analysis and table of specifications for the fifth-grade geometry unit in mathematics

No	Lesson Title	Outputs No	Outputs weigh	Lesson weigh	Lesson's marks	Knowledge mark	Application Mark	Thinking skills mark
1	Polygons	4	%19	%21	5	2.5	1.5	1
2	Triangles	4	%19	%21	6	3	2	1
3	classification of triangles	5	%24	%20	5	2.5	1.5	1
4	Quadrilaterals	4	%19	%18	4	2	1.5	0.5
5	Classification of quadrilaterals	4	%19	%20	5	2.5	1.5	1
Total		21	%100	100%	25	12.5	8	4.5

Validity of the test

The test was presented in its first form to a group of (6) reviewers in the fields of mathematics and curricula, including supervisors and teachers, where they were asked to provide their opinion on the test items in terms of content, wording, the extent to which the items achieve lessons outcomes, and their suitability for fifth-grade students, Their observations were studied ,

as some forms that seemed difficult for students with learning difficulties were deleted and replaced with appropriate ones, and the test time was increased.

Test reliability

The test was applied to an exploratory sample of (24) male and female students other than the study sample, then the reliability coefficient was extracted by Cronbach alpha, by giving the test and then re-giving it after (15) days, the reliability coefficient reached (0.84), which is an acceptable value, as in the table below table (4).

Table (4): A reliability coefficient for the achievement test for fifth-grade students in mathematics

achievement test	Number of questions paragraphs	STD	Arithmetic mean	Cronbach alpha Value
	23	6.55	14.3	0.84

Second tool: Digital content using augmented reality.

Theoretical literature in this field was reviewed, and the geometry unit was studied in fifth-grade mathematics, learning outcomes, resources, and appropriate teaching strategies for it, then the digital content was designed, the researcher used the Adobe Illustrator program which used in some previous studies (Alsaleh, 2020; Hassan, 2018; Al-Ghamdi, 2018).

The Adobe illustrator program was used to design the lesson images, in addition to ready-made images and a sound recording with the images in an integrated manner through the unite AR augmented reality program. A 3D character suitable for the age group was also designed, and the character was animated according to the content with sound recording, as the character, voice, and images in the book were linked together by the Unite AR application.

Validity in Augmented reality technology tool.

The applications lessons was presented to a group of (6) arbitrators specialized in the field of educational technology, from Mutah university and computer teachers in Al-mazar schools, to express their opinions on It, regarding the appropriateness of the content, the clarity of the presentation, and other observations, and the observations were taken into account and the required amendment was made, such as Replacing some geometric shapes with others in the form of cartoon drawings, and adding a folder to save the works that the student can store.

Steps of preparation digital content with augmented reality.

Using the ADDIE model of instructional design, the digital content was designed, and the approved model consisted of 5 stages as follows (Alsaleh, 2020):

The first stage

needs and content are identified as previously presented, and the target group is analyzed, who are fifth-grade students who have a similar level of learning difficulties, and who have smart devices and can deal with them.

Second Stage

Transforming the analysis stage into operational steps by defining goals and teaching methods.

Educational goals

- The student distinguishes polygons.
- To determine the type of congruence in triangles.
- To classify the types of triangles according to the measure of an angle.
- To classify quadrilaterals by name.
- Teaching style, Using the display by applying augmented reality, with a learning strategy through dialogue and educational activities.

Third Stage: Development Stage.

In this stage complete composing and production of all Teaching aids that will use in the operation educational, and design of the test achievement. And completed Produce technical elements indeed enhanced like pictures and personality (3D) considering, that it is in line with the content and appropriate to the age group and that it is clear, and for the sound, it is clear and not distorted and appropriate for the presented material, and the following programs have been used to design content with augmented reality:

- Adobe Illustrator program.
- program Unite AR.
- program to design Characters (3D).

The fourth stage: The implementation stage.

The specific lessons were explained to the experimental group using augmented reality, which needs about 8 lessons over 2 weeks, and the control group uses the traditional way of learning at the same time.

The fifth stage: Evaluation stage.

The achievement test prepared for this study was applied to the two groups, to see the effectiveness of teaching with augmented reality.

6.5 Procedures

The procedures followed in This study are as follows:

- Mental perception of the problem of the study and return to the theoretical literature and previous studies related to it.
- Presenting theoretical literature related to the subject of the study.
- Determine the study problem and its questions and hypotheses.

- Reviewing mathematics for the fifth grade, identifying lessons from a specific unit that are suitable for teaching them in augmented reality, and analyzing their content.
- Building lesson material with augmented reality and building an achievement test.
- Obtaining a letter from the Directorate of Education of the Southern Mazar District for the application of the study in Mutah Elementary Mixed School.
- Training the mathematics teacher to teach students with learning difficulties using digital content, to assist in the application process.
- Presenting the classes allocated to the experimental group, and supervising the classes provided to the control group. The students taught the lessons for 8 lessons and one for the post-test for the two groups. The duration of one lesson was 45 minutes.
- The data was collected and analyzed, and the results were presented and discussed.

7. Results and Discussion

The data was analyzed and the results with discussion were as follows:

The first study hypothesis

There are no statistically significant differences at the level ($\alpha < 0.05$) between the mean scores of the control and experimental groups on the achievement test of the fifth-grade students with learning disabilities in Mutah Basic Mixed School due to the teaching method.

The analysis shows the arithmetic means and standard deviations for the two groups in the achievement test, in table (5).

Table (5): The means and standard deviations of the achievement test results in mathematics

Group	Number	Pre test		Post test	
		Mean	STD	Mean	STD
Control group	20	16.4	3.66	19.8	2.61
experimental group	20	15.7	4.2	22.7	2.67

The mean of the experimental group on the post-test was (22.7) in contrast, the mean of the control group was (19.8), which indicates a difference between the mean values between the two groups.

There were differences in the two methods of education, and to know the significance of these differences statistically and in favor of which group. ANCOVA analysis of variance was used to confirm the effect of the extraneous variable, which is the post-test for the two groups, in Table (6) the results of the analysis are shown below.

Table (6): Analysis of (ANCOVA) to examine the differences between the two groups at the level of post-application of the achievement test

Source	Sum of Squares	Df	Mean Square	F	Sig.*
Intercept	135.25	1	135.25	47.63	0.000
Error	19.08	1	19.08	7.130	0.007

Total	89.75	38	2.001
Corrected Total	250.07	37	

* $\alpha < 0.05$

Through the table, the value of the calculated level of significance is 0.007, which is less than the value of 0.05, that means the hypothesis is rejected and indicates the existence of statistically significant differences between the Means of the two groups due to learning by augmented reality.

It is clear from the table that there are statistically significant differences at ($\alpha < 0.05$) level between the mean scores of the students in the control and experimental groups, in favor of the experimental group, that learned by augmented reality, with a large effect size as in Table (7) below.

Table (7): Value Square eta (η^2) to measure the size effect of the Augmented Reality technique in teaching between two groups

Application	No	Full mark	Mean	Df	T value	Square eta (η^2) *	effect size
Controlling group	20	25	19.8	38	11.082	0.460	Big
experimental group	20		22.7				

* $\eta^2 > 0.14$

Table (7) shows that there is a significant impact of teaching with augmented reality technology for fifth-grade students with learning difficulties, in mathematics on their achievement, as the value of the square of Eta (η^2) is 0.460.

And the adjusted achievement means for the students with learning disabilities in the post-measurement were calculated as in table (8).

Table (8): Modified arithmetic means and standard errors of achievement post-test scores

Group	Number	Modified arithmetic means	standard error
Control group	25	19.62	0.401
Experimental group	25	21.98	0.401

Table (8) shows that there are differences in the impact of the two teaching methods for students, in favor of the experimental group and learning through augmented reality.

The presence of an effective and significant impact of the augmented reality teaching method, came from the fact that augmented reality applications provide a rich and motivating environment to achieve the planned goals, and also help to increase the concentration of students with learning disabilities, who may face cases of dispersion and lack of focus at times, as it helps them to imagine situations and store images, information and recall them easily (Al-Saqriya and Al-Salmi, 2020; Al-Ghamdi, 2018).

Augmented reality technology also includes several stimuli, allowing an individual or group interaction, and achieving harmony and compatibility with it, as students extract from the content of the restricted book to provide it with pictures, videos, and learning patterns that are more attractive to learning, with different learning styles (Aql, 2014; Haitham, 2018).

The researcher believes that the capabilities of augmented reality include different learning styles, that can be used with consideration of individual differences among students, and the diversity between the application's exhibits of three-dimensional images, models, and videos that make students in general and students with learning difficulties more attentive, and present during the lesson, and reduce distraction times and lack of focus. And because of cases of learning difficulties, students may differ in their details from one student to another, individual learning can be done to review or solve activities, and students will get rid of the routine of regular classes that often make them feel bored. Also, they suffer from dealing with abstract math concepts, and difficulty in imagining, which made augmented reality a suitable way for them to learn,

Many previous studies supported this current study's result, and indicated the effectiveness of augmented reality in teaching, with different samples (Renner, 2014; 2015; Al-Maalawi; Dulaimi, 2020, Al-Maalawi, 2016).

There are no studies got a result in no effectiveness to use (AR) technology in learning until the year 2022.

The second hypothesis

"There are no statistically significant differences at the level ($\alpha < 0.05$) between the means of the control and experimental groups on the achievement test of the fifth-grade students with learning difficulties in Mutah Mixed Basic School, in favor of teaching with augmented reality, due to the gender variable.

Analysis was used by ANOVA to reveal the effect of the gender variable on the post-achievement of students, who studied by applying an augmented reality, table (9).

Table (9): One-way analysis (ANOVA) to investigate the effect of the gender variable on the post-achievement of the experimental group

	Sum of Squares	df	Mean Square	F	Sig.*
Between Groups	.800	1	.800	.291	.596
Within Groups	49.400	18	2.744		
Total	50.200	19			

* $\alpha < 0.05$

In table (9) the calculated F value was (0.291) and that the level of significance was (0.596), which it is greater than 0.05 [$F = 1,19 = 0.291$, $P = 0.596$], It means that there is no effect of the gender variable on the achievement of the experimental group in the post-test.

That means all students (males and females) interacted with augmented reality and sought to understand the mathematics lessons provided, and there were no differences in the performance of males and females, because they have the same learning disabilities, and learn with the same ways in the school, live in similar social and educational environment.

Also, the (AR) applications in teaching helps all students to understand and interactive with lessons, because they have different levels of learning which student can choose any level then

continue to others, until he understands lessons better, so the gender variable will not affect the degree of achievement.

This result was consistent with the results of several studies that examined the effect of gender on students' achievement or their motivation for achievement after teaching with augmented reality. (Pan, 2020; Yildirim, 2020; 2015).

8. Recommendations

The study recommends the following:

1. Using augmented reality (AR) applications in teaching, providing methodological and enriching activities for students, as the needs of students with learning difficulties.
2. Encouraging teachers to learn using augmented reality and integrate it into regular learning, is one of the active learning methods.
3. Activating the technology of augmented reality, and the capabilities it offers to teach many topics to students with learning difficulties, especially learning abstract concepts, and working with various activities.
4. Integration of augmented reality technology to teach mathematics to students with learning disabilities.
5. Conducting more studies in the field of augmented reality, education, and assessment processes in Arab environments.
6. Conducting more researchs on the impact of the effectiveness of teaching with augmented reality, for other subjects and students with learning difficulties from different stages.
7. Researching obstacles of using augmented reality in Jordanian learning environments.

Conflicts of interest statements

All authors declare that they have no conflicts of interest.

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