

The Extent of Using Augmented Reality Technologies in Improving the Abilities of Students with Learning Difficulties (Dyscalculia) in Learning and Achievement

Ibraheem Abdullah Alzahrani

Educational College, Al-Baha University, KSA

ABSTRACT

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Correspondent Author:
Ibraheem Abdullah Alzahrani
E-mail: iaalzahrani@bu.edu.sa

KEYWORDS

E- Learning, Technology innovations, Augmented Reality, Learning disabilities, Effectiveness.

The current study sought to determine the effectiveness of an innovative approach in learning "Augmented Reality Technology" (ART) in improving the abilities of students with learning difficulties which called "learning disabilities" (Dyscalculia). The researcher adopted an experimental approach with two groups; a control group of students who learned using traditional approaches and an experimental group using ART. The study sample consisted of all of students with learning disabilities from grade 4 in Balragosh Elementary School during the first semester of 1437-1438 AH. The researcher used (ARUSMA) application, as an ART. To measuring the attitude scale, the researcher used Arithmetic Average, standard deviation, Pearson's correlation coefficient, (ANCOVA) and T-Test. The results showed that there are statistically significant differences between the modified averages of the experimental and controlling group in the level of significance ($\alpha \leq 0.05$) in the post-measurement in the levels (Remembering, Understanding and Analysis) for the favour of the experimental group. The result also shows that there are a statistically significant differences to the post-achievement of the study sample for the favour of the experimental group. According to these results, the researcher suggested to make use of this technique in teaching students in other courses and to implementing it with other levels and providing decision-makers with recommendations and suggestions.

مدى امكانية استخدام تقنية الواقع المعزز في تنمية قدرات الطلبة ذوي الاحتياجات الخاصة (صعوبات التعلم Dyscalculia) في التعلم والتحصيل

ابراهيم عبدالله الزهراني

كلية التربية ، جامعة الباحة ، المملكة العربية السعودية

المستخلص

سعت الدراسة الحالية الى تحديد مدى امكانية استخدام احدى تقنيات التعليم الحديثة في التعليم واثراها على تحصيل طلاب ذوي الاحتياجات الخاصة فئة صعوبات التعلم مع التركيز على احدى جوانب صعوبات التعلم وهو ما يعرف بعجز الرياضيات Dyscalculia أو العسر الحسابي. طُبِقَ في هذه الدراسة تقنية الواقع المعزز (Augmented Reality (AR باستخدام تطبيق Aurasma بهدف وضع المتعلم في بيئة تعليمية تفاعلية جاذبة. استخدم الباحث المنهج التجريبي التصميم شبه التجريبي لمجموعتين ضابطة تعلمت بالطريقة التقليدية، وتجريبية استخدمت تقنية الواقع المعزز. تكونت عينة الدراسة من 8 طلاب يمثلون العدد الكلي لطلاب صعوبات التعلم في الصف الرابع الابتدائي بمدرسة "بالرقوش" الابتدائية بمنطقة الباحة التعليمية في مقرر مادة الرياضيات. طُبِقَت الدراسة خلال الفصل الدراسي الأول من العام الدراسي 1437-1438 هـ. تم تحليل النتائج باستخدام المتوسطات الحسابية والانحرافات المعيارية، ومعامل الارتباط بيرسون وتحليل التباين المشترك (ANCOVA)، وكذلك اختبار (ت) (Paired Samples Test) للتعرف على الفروق ما بين متوسطي القياس القبلي والقياس البعدي لطلبة المجموعة التجريبية في مقياس الاتجاه. توصلت الدراسة الى وجود فروق ذات دلالة إحصائية عند مستوى الدلالة ($\alpha \leq 0.05$) بين المتوسطات المعدلة للمجموعتين التجريبية والضابطة في التحصيل البعدي عند مستويات (التذكر، الفهم والتحليل) لصالح المجموعة التجريبية. وفي التحصيل البعدي الكلي لصالح المجموعة التجريبية. قدم الباحث مجموعة من التوصيات للاستفادة من هذه التقنية في التدريس وتطبيقها أيضا على مراحل الدراسة المختلفة مع تقديم توصيات ومقترحات لذوي القرار في التعلم.

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بريد الكتروني: iaalzahrani@bu.edu.sa

الكلمات الدالة

التعلم الالكتروني، مستحدثات التكنولوجيا، الواقع المعزز، صعوبات التعلم.

Introduction

Using technology in teaching process is one of the needs that the educators agreed upon their importance in the educational field. (Eyadat, 2004, p. 106) stated that, “it is clear that using computers is a continuous supplementary mean for the educational institution. In the last two decades, it became noticeable that many of the educational staff in universities use computers in their courses”.

Technology allowed many new ways of teaching and learning since it provided teachers with techniques that may be used to enhance learning and increase students' achievement. As a result, many new methods of teaching and learning appeared. On one hand, the international educational conferences support this trend. For example, the first scientific conference of the Arab Institution for Education Technology (2005) suggested: “highlighted the importance of benefitting from the local and international experiences in the field of technological development, in addition, to make the use of educational technology applications to improve the quality of teaching process”. (Nofal, 2010, p. 17). Since ART provides an important, modern and supportive aid to teaching processes, it is a main factor to be considered in improving teaching. The literature has shown that ART has an important role to play in enhancing learners' awareness of curricula concepts. Wang (2014) also confirmed that students' interaction with the subject was better as a result of using ART in learning. The researcher believes that studying the effectiveness of ART in increasing the achievement of students with learning disabilities supports efforts to mitigate some of the stress of these students are exposed to.

Significance of the study

Students who suffer from dyscalculia often face obvious problems, even in solving the simplest math problems, and have obvious problems in understanding basic mathematical principles. Moreover, learning of sequential mathematical procedures or basic mathematical concepts (e.g., Addition, Subtraction, Multiplication, Division) are also a major challenge. Disability is one of the most common disabilities among school

students. In this regards, out of every 20 students, one is suffering from dyscalculia. Although this phenomenon is a type of learning disability and is caused by a simple brain disorder in certain parts of the brain responsible for mathematical cognition, many of the problems associated with it may result from dislike and avoid the student to mathematical matters wherever he or she can do. Hence, Study significance comes from the need to provide both learners, parents, and teachers with new learning technology, and to meet the dramatically increasing in using the educational technology innovations. In this regard, the researcher sought to review the main motives and justifications that are derived from two main aspects:

Regarding the study society

As a faculty member of the Educational Technology Department and by teaching the courses that are relevant to Special Education Department, the researcher found that using education technology, especially with students with learning disabilities, can help them in many fields. First, it helps them to overcome the difficulties they face in dealing with particular educational processes, such as understanding, pronunciation, thinking, attention, spelling, and cognition. In addition, it assistances students to overcome difficulties related to reading and writing, as ART has certain advantages than other modern teaching techniques such as using smart board. By looking at statistics relevant to the use internet and tablets, the researcher believes the recent trend in the use of technology can help students with learning disabilities. According to the communication and information technology commission (2016), the Saudi Telecommunication Authority showed high averages of using the internet during the last six years, from 41% in 2010 to 70.4% in 2016, there was 22.3 million of users, and accordingly, students' desire to have and use smartphones enhances the attraction of using technology in educational processes.

Regarding recommendations of previous studies, conferences and seminars

The researcher looked at the recommendations of many previous scientific conferences and studies. For example, the first scientific conference of the Arab Institution for Education Technology (2005) in Egypt talked about the technologies and how to connect it with students with learning disabilities, and recommended to benefit from the local and international experiences in the field of technological development, and the educational technology and telecommunication applications to facilitate the quality of the educational process. The conference pointed out the role of the technologies in facilitating understanding. Studies such as Nofal (2010); Barreira, Bessa, Pereira, Adao, Peres, and Magalhaes (2012); Ivanova and Ivanova (2011), Indicated that students with learning disabilities are abnormally quiet, and that they withdraw themselves from any social situation. In addition, they often do not have friendship relationships, which can cause a decrease in the number of friends in their social group and a fear of creating new social relationships

Study Questions and Hypotheses

The current study attempted to answer the following questions:

- 1- How effective is using ART in improving students with learning abilities (dyscalculia) from grade four in Mathematics?
- 2- Are there any statistically significant differences between the study groups when using ART to learn Mathematics?
- 3- What are the attitudes of students with special needs towards using ART in their Mathematics studies?

Hypotheses

- 1- There are statistically significant differences in the level of significance ($\alpha \leq 0.05$) between the modified averages of the experimental and control groups in the post-achievement in memory of students with learning disabilities from grade four after controlling for pre-achievement.
- 2- There are no statistically significant differences in the level of significance ($\alpha \leq 0.05$) between

the modified averages of the experimental and control group in the post-achievement in level of understanding of students with learning disabilities from grade four after controlling for pre- achievement.

- 3- There are no statistically significant differences in the level of significance ($\alpha \leq 0.05$) between the modified averages of the experimental and control group in the post-achievement in application levels of students with learning disabilities from grade four after controlling for pre-achievement.
- 4- There are no statistically significant differences in the level of significance ($\alpha \leq 0.05$) between the modified averages of the experimental and control group in the total post-achievement of students with learning disabilities from grade four after controlling for pre-achievement.
- 5- There are no statistically significant differences in the level of significance ($\alpha \leq 0.05$) between the averages of the pre- and post-measurements of the experimental group in the attitude scale.

Study Objectives

The current study aims to:

- 1- Define the effectiveness of using ART in improving students' abilities with learning disabilities in Mathematics.
- 2- Determine the statistic differences between the experimental and control groups to reveal and understand the effectiveness of using ART with students with learning disabilities.
- 3- To find out the attitudes of students with learning disabilities towards using ART in Mathematics.

Limitations of the Study

This study is restricted to students with learning disabilities from grade four from Al-Baha city as thematic limitations to find out the effectiveness of using ART in learning Mathematic curriculum and to improve the abilities of students with learning disabilities. The current study was also applied during the first academic semester of the year (1436- 1437AH), thus providing time limitations to the study.

Terminology

This section contains of several terms to provide the reader with clear understanding of the study concepts, in specific context and specific meanings. Terminology shows the interrelationships between the study terms:

Effectiveness

Educationally, Al- Harbi (2006) defined effectiveness as a way of teaching that involves learners in doing things that force them to think about what they are learning. Effectiveness is measured by knowing the effect of the independent variable on the dependent variable through tests and scales. In order for learning to be effective, learners should engage in reading, writing, discussing or solving a problem with what they are learning or doing a test. Further, effective learning is what requires learners to use higher thinking tasks such as analysis, synthesis, and evaluation in relation to what they learn.

Based on the above, the researcher procedurally defines effectiveness as:

The amount of change in students' achievement, which results from using ART with students with learning disabilities in Mathematics.

Augmented Reality

Azuma (1997, p365) defined ART as a technique different from the virtual reality that gets the user inside an artificial environment. ART is characterized by its interactivity and joining part of the virtual reality with the real world in addition to adding 3D shapes.

Procedurally, the researcher defines ART as:

Using electronic devices that are suitable to the characteristics of the ART that transfers texts and images into a living environment using an application.

Skills

The term "Skills" has been defined as "reaching the degree of mastery that helps the worker doing it so easily in addition to being safe and avoiding dangers and faults" (Abu Farwa ,1997, p58).

The researcher procedurally defines skills as:

Achieving the objectives of studying Mathematics with the required efficiency and quality on time.

Learning Disabilities

Abu Shaira and Thaer (2009, p27) defines learning disabilities as, "disorder resulted from psychological functional factors that may be resulted from a functional disorder in nerves and brain. This disorder in person's mental abilities affects his academic achievement in reading, writing, spelling and many other skills."

The researcher defines learning disabilities as:

A group of the mental factors of a group of learners preventing them from academic achievement similar to their classmates without any physical or clear mental disability.

Dyscalculia

The term Dyscalculia refers to a specific learning disability in math, students with dyscalculia struggle of the difficulty of understanding the numbers and the vocabulary in math questions. Kim, et, al., defined "dyscalculia" as a mathematical learning disability that affects the ability to perform operations and make the proper use of arithmetic. Dyscalculia, can be characterised as a learning disorder in which a person's mathematical ability is considerably below the normal level expected based on his or her age, life experiences, intelligence, physical impairments, and educational background. This disability affects the ability to do calculations as well as the ability to understand word problems and mathematical concepts. The researcher follow the definition of Kim, et, al., that has been mentioned above.

Students with Learning Disabilities

The researcher believes that it is not enough to define "Learning Disabilities" without knowing the characteristics of students who are considered to have learning disabilities. This is because the first term 'learning' defines the concept, and the second 'disabilities' defines the psychological and behavioural characteristics of students with

learning disabilities. Melhem (2002, p42) mentions the definition of (ACLD) for the child with learning disabilities as, “the child with suitable mental ability and sensory processes in addition to emotional stability, but he has a limited number of disabilities of perception, integration and expressive processes and this severely affects his ability to learn. On the other hand, Rasher (2002, p32) defines children with learning disabilities as “children whose intelligence average is between (70- 90) according to intelligence tests. Disability appears by the slow of their learning of the academic skills in addition to their mental skills.”

The researcher defines students with learning disabilities as:

Students without physical, psychological or mental disability, but with some real disorders preventing them from achieving as their classmates.

Framework and Literature Review

This section starts with a discussion of the conceptual framework as components of the study. This discussion includes similarities and distinctions among these components with an overview of the literature review, and the relation of the literature with the current study.

Augmented Reality

In Arabic, there are many synonyms for the term Augmented Reality (AR). The reason for this difference in the Arabic terms lies in the difference in the translation of the English term, which is based on two things. The first is literal translation, while the second, which the researcher believes to be the right way to deal with the modern technical term, is the modern technical term. The researcher uses the modern technical terms, so the term AR was chosen in this study. The term AR is considered as an addition to the digital data and its format in addition to using digital ways for the reality of the environment surrounding people from a technical perspective. AR (Figure 1) is usually related to computers that may be worn or smart phones that may be handheld (Larsen, Bogner, Buchholz and Brosda, 2011).



Figure (1): Using digital devices in ART Virtual and Augmented Reality

The Virtual Reality transfers the user from his/her concrete reality into the virtual reality by moving the user's senses. This makes the user respond and interact with this virtual environment. By contrast, ART deals with the real environment and incorporates the virtual data with the real world. This incorporation aims at enriching the real environment with data for various goals in different fields as shown in table (1):

Term	Augmented Reality	Virtual Reality
Description	Projection of virtual data in a real environment	The whole incorporation of the user with a virtual environment simulating reality
Required Equipment	Smart Phones Tablets Computers	(IU) such as, Joystick, Touch Gloves and Helmet
Required Software	3D max Maya Adobe after effects Layer, Jmtaio	(OU) such as 3D Displays. 3D max Maya Adobe primer
Controlling senses	The user keeps his feeling of the real environment.	Virtual environment controls senses
Work Environment	It deals with a real environment with real existence.	It depends on a wholly virtual environment
Usage	It is used in many fields including education, manufacturing, medicine, construction, marketing, entertainment, tourism and military training	Virtual Educational Environment Virtual Media Environment Virtual Medical Training Entertainment on a virtual enviroment

Table (1): Comparison between augmented and virtual reality

Learning Disabilities

Terminology surrounding ‘learning disabilities’ was unclear before the appearance of the term between 1930 and 1960. Hallahan and Kauffman (2000) named many terms as the simple imbalance in a brain’s functions, language disorders and neuromuscular handicaps (Dyslexia). After looking at studies related to learning disabilities, the researcher sees that the term appeared in the beginnings of the 1960s. Kirk (1997) suggested the term “Disability” to join the meanings of the previous terms and to describe children with normal intelligence compared with their classmates, but who faced some disabilities with learning. The researcher agrees with Coles (1989, p 267), who stated in his study that “learning disabilities is a modern field in the field of private education compared with traditional methods such as visual disability, hearing impairment and mental retardation. Learning disability was not known as a field of private education until the middle of sixties”.

The Spread of Learning Disabilities

The American Bureau of Education estimated the prevalence of learning disabilities in 1978 at 1.89% of individuals aged 3-21 years (Mercer, 1983, p48) and therefore, according to the American Education Centre, the average had risen by 1986 to approximately 4.73% (Hallahan and Kauffman, 2000, p106). Therefore, researchers specialized in learning disabilities agree in that, having comprehensive updated statistics for all learning disabilities are very complicated. For instance, Khateeb and Hadidi (1997, p80) stated that, ‘‘estimates of numbers and averages of children with learning disabilities are so different since the definition is unclear and there are no available tests for diagnosis.’’ However, there are statistics for specific types of learning disabilities in certain countries, as shown in table (2):

Country	Percentage	Country	Percentage
Belgium	5%	Britain	4%
Yugoslavia	2-3%	Finland	10%
Greece	5%	Italy	1-5%
Japan	6%	Nigeria	11%
Norway	3%	Russia	10%
America	9%	Poland	4%

Table (2): An example of the spread of learning disabilities.

Source (Salter, Everatt and Smythe.2005)

Literature review

After looking at the educational studies and searching database related to using modern technological techniques in teaching, the researcher found that Arabic studies talking about ART are rare.

McMahon, Cihak and Wright (2015) compared the instructional effectiveness of a location-based augmented reality navigation tool with Google maps and print-based material on students diagnosed with intellectual disabilities or autism spectrum disorder and found that students were better in travelling with the help of location-based augmented reality navigation tool. In this regard, Wang (2014) found that augmented reality simulation leads to a more active role among students in collaborative learning than traditional learning styles. In a comparison study of the use of media in education, Han, Jo, Hyun and So (2015) studied how using computers versus robots might have an effect on nursery students' awareness toward augmented reality-pervaded dramatic play, however, the results indicated that, children tended to have higher satisfaction with augmented reality infused dramatic play regardless of the type of which media used. The use of ART in learning leads to increase the self-learning and the interaction among students and their enthusiasm to learn (El-Sayed, 2011) Fonseca, Marti, Redondo, Navarro and Sanchez (2013). Moreover, Chen and Tsai, (2011) found that, students' interactivity, their desire to read and the search for the information also increases when using ART in learning. Bacca, Baldiris, Fabregat and Graf (2014) emphasises that the use of augmented reality in education assists students to actively engage in

discussions with others and also with their learning, both activities leading to more positive attitudes and improved learning performances.

Despite these positive attributes, effectively integrating emerging technologies such as ART into education has several challenges which need addressing (Martins, Gomes and de Paiva Guimarães, 2015). For example, traditional learning methods poses problems around a clash of styles with the new technologies, while the costs involved in the development and maintenance of ART systems and devices need to be considered; both issues create a general resistance to new technologies (Lee, 2012). The study may reveal the point that how educators and researchers approach integrating augmented reality applications into teaching-learning processes. Technical obstacles and the ineffectiveness design of augmented reality applications are considered to have an inhibitor effect for educators during the integration process.

Nevertheless, it is recommended that there is a need for an ongoing exploration to determine and create a 'conventional wisdom' to demonstrate how either new media and/or emerging technologies, such as augmented reality applications, and pedagogical approaches or methods together, have positive effects on students' learning outcomes. Bacca et al,(2014), Estapa and Nadolny, (2015).

Study Methodology

The researcher used a semi-experimental approach and experimental control with two groups to show the effect of the independent variables. The first group, which was taught using the traditional method, is the experimental group. The second group, taught the same educational content but instead using ART, was the control group.

Participants

Study Population: population of the current study includes all fourth graders with a learning disability in Mathematics in Al-Baha elementary schools.

Study Sample: The sample, formulated from data supplied by the Department Of Teaching And Learning in the General Directorate of Education in Al-Baha. The study involved eight students which

was divided into two groups of four students. The sample was intentionally chosen, while the two groups were randomly chosen to present the study population.

Variables of the Study

Independent Variable: the factor which was applied to know its effect on the result. The independent variable in this experiment was the effect of applying ART.

Dependent variable: the result on which the effect of the independent variable is measured. The dependent variable of the current study is the academic achievement of students with learning disabilities in the three levels (remembering, understanding and analysis) in Mathematics.

Data collection and analysis

This section addresses the steps of designing and conducting the achievement test. discusses the hypothesis of present study and to compare the results with the another results in literature.

Forming an Achievement Test (Pre- and Post-Test):

The researcher was careful to insure reliability of the test and followed the following steps:

Identification of the goal of the test
Formulation of the achievement test
Content reliability of the test
Defining time of the test
Measuring coefficient of ease, of difficulty and of discrimination

Statistical Means Used in the Study

The researcher used many statistical means to analyse data of the current study. Coefficient of Ease, difficulty and discrimination of the achievement test were measured. The 'Coefficient of Difficulty' defines the difficulty of the test and refers to the percentage of students who answered the question correctly. Coefficient of Difficulty was measured according to the following equation:

$$\text{Coefficient of Difficulty} = (s/n) * 100\%$$

The 'Coefficient of Ease' was measured according to the following equation:

$$\text{Question ease} = 1 - \text{Coefficient of Difficulty}$$

'Coefficient of Discrimination' = $\frac{\text{sum (a)} - \text{sum (b)}}{\text{sum (m*n)}}$

The researcher used this equation as the questions of the achievement test were multi-choice rather than essay questions, which are more appropriate for such types of questions. The results of these equations are shown in table (3):

No.	Coefficient of Ease	Coefficient of Difficulty	Coefficient of Discrimination	No	Coefficient of Ease	Coefficient of Difficulty	Coefficient of Difficulty
1	0.141	0.125	0.485	16	0.155	0.112	0.443
2	0.112	0.155	0.443	17	0.141	0.125	0.485
3	0.099	0.168	0.400	18	0.101	0.165	0.384
4	0.155	0.112	0.443	19	0.123	0.144	0.491
5	0.165	0.101	0.357	20	0.133	0.133	0.533
6	0.123	0.144	0.491	21	0.088	0.179	0.347
7	0.112	0.155	0.443	22	0.181	0.085	0.357
8	0.155	0.112	0.443	23	0.181	0.085	0.357
9	0.168	0.099	0.400	24	0.099	0.168	0.400
10	0.101	0.165	0.384	25	0.088	0.179	0.357
11	0.133	0.133	0.533	26	0.112	0.155	0.443
12	0.101	0.165	0.384	27	0.112	0.155	0.443
13	0.133	0.133	0.533	28	0.099	0.168	0.400
14	0.112	0.155	0.443	29	0.123	0.144	0.491
15	0.112	0.155	0.443	30	0.12	0.147	0.491

Table (3): Coefficients of Ease, Difficulty and Discrimination

It was clear that the average Coefficient of Discrimination of part of the test was suitable and the researcher made the decision to use 40% coefficient of discrimination since this leads to a good achievement test.

Measuring Stability of the test using equation of Kuder-Richardson (KR-20)

Coefficient of Stability of the achievement test was measured using KR-20 equation. The researcher chose this equation because it is the most commonly used with tests determining one point for the correct answer and zero for the incorrect answer. An ANCOVA test was used to determine the differences between the modified averages of the experimental and controlling group in the post test after controlling the pre-achievement. A Paired Sample Test was used to determine the differences between the averages of the pre- and post-measurement of the experimental group in an attitude scale. (η^2) was used to measure the size of effect of using ART to improve the abilities of students with learning disabilities and their attitudes.

Source of variation	Squares Sum	Freedom degrees	Squares average	F	significance	η^2	Size of the effect
Pre-test	0.278	1	0.278	1.452	0.312		
Between the groups	83.349	1	83.349	85.65	0.001	0.3424	middle
Mistake	50.283	4	0.898				
Total	133.91	6					

Table (5): The differences between the modified averages of the two groups in the post test in remembering levels after controlling the pre-achievement

Table 5 shows that there are no differences between the modified averages of the two groups in the post-achievement in remembering levels of fourth graders with learning disabilities in Mathematics after controlling pre-analysis.

To determine the difference, the researcher looked at the modified averages of the experimental and control group. Table 6 shows these differences.

According to KR-20 (Table, 4) the number of students in the lower group who got the item correct has been subtracted from the number of students in the upper group who got the item correct. Then, the number of students in each group divided as follows.

N	A	Sum (s*k)	(KR-20)
30	0.746	0.779	0.932

Table (4): coefficient of stability of the achievement test using equation of Kuder-Richardson

By compensating in the equation, KR-20 = 0.932. This confirms that the test is stable.

Results and discussion

The first hypothesis: There are statistically significant differences in the level of significance ($\alpha \leq 0.05$) between the modified averages of the experimental and control group in the post-achievement in remembering level of students with learning disabilities for grade four after controlling the pre-achievement.

Group	Modified Average
Control Group	4.98
Experimental Group	7.56

Table (6). Differences between the modified averages of the post achievement of the experimental and controlling group in remembering level.

The size of the effect of using ART in increasing the academic achievement of the experimental group can be seen in table (5) η^2 was (0.3424), and this indicates a middle effect size. This result agreed with Han et al, (2015), El-Sayed, (2011), Fonseca, et al. (2013), Chen and Tsai, (2011).

The second hypothesis: There are no statistically significant differences in the level of significance ($\alpha \leq 0.05$) between the modified averages of the experimental and control group in the post-achievement in understanding level of students with learning disabilities for grade four after controlling the pre-achievement.

Source of variation	Squares Sum	Freedom degrees	Squares average	F	significance	η^2	Size of the effect
Pre-test	0.199	1	0.199	0.982	0.312		
Between the groups	20.063	1	20.063	185.353	0.001	0.44	middle
Mistake	4.950	4	0.088				
Total	25.211	6					

Table (7): The differences between the modified averages of the two groups in understanding level after controlling the pre-achievement.

Table 7 shows that there are differences between the modified averages of the experimental and control groups in the post-achievement in understanding level of students with learning disabilities after controlling the pre-analysis. As shown in Table 7, the level of significance is less than (0.05), and its value is (0.001) while F is (185.353). To know the differences direction, we have to look at the modified averages of the two groups. Table 8 shows these differences.

Group	Modified Average
Control Group	2.91
Experimental Group	5.45

Table (8). The differences between the modified averages of the post-achievement of the experimental and controlling group in understanding level.

To know the size of the effect of using ART in increasing achievement of the experimental group, can be seen in table (8). It is clear that (η^2) was (0.44), which indicates a middle effect size.

The third Hypothesis: There are no statistically significant differences in the Level of Significance ($\alpha \leq 0.05$) between the modified averages of the experimental and control group in the post-achievement in analysis level students with learning disabilities from grade four after controlling the pre- achievement.

Source of variation	Squares Sum	Freedom degrees	Squares average	F	significance	η^2	Size of the effect
Pre-test	0.0005	1	0.0005	0.004	0.009		
Between the groups	8.683	1	8.683	75.235	0.001	0.372	middle
Mistake	4.329	4	0.898				
Total	13.013	6					

Table (11): The differences between the modified averages of the two groups in the total post-achievement after controlling pre-achievement.

Table 11 shows that there are differences between the modified averages of the experimental and controlling group in the total post-achievement of students with learning disabilities from fourth grade after controlling pre-analysis. As shown in the table, the level of significance is less than (0.05), and its value is (0.001), while (F) value is (278.256).

Group	Modified Average
Control Group	10.21
Experimental Group	16.1

Table (12): The Difference between the modified averages of the total post achievement of the experimental and controlling group.

Table 12 shows that there are differences between the averages of the controlling and experimental group in the total post achievement for the side of the experimental group. To know the size of the effect of using ART on increasing the academic achievement of the experimental group, we look at the value of (η^2) in Table 13. We can notice that the value of (η^2) is (0.372), which indicates a middle effect size.

The effect of using ART in increasing the achievement in the three levels (Knowledge, Understanding and Analysis), in addition to raising the total post achievement of students with learning disabilities in Mathematics, is as the following:

- 1- The difference between the teaching approach using ART and the traditional approach allows students with learning disabilities in Mathematics to see shapes in a holographic way, which simplifies solving mathematical calculations.
- 2- Activities and applications designed using ART include immediate feedback, which enables students with learning disabilities in Mathematics to correct errors by themselves, which increases their academic achievement.
- 3- Activities and applications designed using ART include skills of searching, investigation and analysis.
- 4- These skills help students with learning disabilities in Mathematics to enrich and improve their educational skills.
- 5- ART supports connecting parts of a lesson and also different lessons with each other, which increases students' achievement.

These results agree with the results of Freitas and Campos, (2008), Sumadio and Rambli, (2010), Ivanova and Ivanov, (2011), Barreira, et al., (2012), Hou, et al. (2013).

The fifth Hypothesis: There are no statistically significant differences in the level of significance ($\alpha \leq 0.05$) between the averages of the pre- and post-measurements of the experimental group in the attitude scale.

Attitude Scale	Test	No.	Arithmetic Average	Standard Deviation	Freedom Degree	T Value	Significance	μ	Effect Size
Personal	Pre	8	1.664	0.435	7	2.365	0.001	0.49	High
Attitude	Post	8	3.189	0.278					
Educational	Pre	8	1.344	0.190	7	2.365	0.001	0.51	High
Attitude	Post	8	2.517	0.207					
Total	Pre	8	1.749	0.351	7	2.365	0.001	0.50	High
	Post	8	2.357	0.332					

Table (13): The differences between the pre- and-post measurement of the experimental group in attitude scale.

To insure the fifth hypothesis, (Paired Samples Test) was used. Table 13, concludes the following:

- 1- There is a statistically significant difference between the averages of the pre- and post-measurement of the experimental group in a level less than (0.05) in the attitude scale (student's personal attitude towards using ART in Mathematics lessons). The statistically significant difference was for the side of the post-measurement that has a higher average. The arithmetic average of the post-measurement was (3.189), while the arithmetic average of the pre-measurement was (1.664).
- 2- There is a statistically significant difference between the averages of the pre-and post-measurement of the experimental group in a level less than (0.05) in the attitude scale (the educational attitude towards using ART in Mathematics lessons). The statistically significant difference was for the side of the post-measurement that has a higher average. The arithmetic average of the post measurement was (2.517), while the arithmetic average of the pre-measurement was (1.344).
- 3- There is a statistically significant difference between the averages of the pre- and post-measurement of the experimental group in a level less than (0.05) in the attitude scale (the total attitude towards using ART in Mathematics lessons). The statistically significant difference was for the side of the post measurement that has a higher average. The arithmetic average of the post measurement was (2.357), while the arithmetic average of the pre-measurement was (1.749). This result agrees with the result of many studies, which concluded the effectiveness of using ART in improving students' attitudes towards using modern techniques in teaching-learning processes such as the studies of Chen and Tsai, (2011), Barreira, et al., (2012), Perez-Lopez and Contero, (2013), Sumadio and Rambli, (2010), Shea, (2014) and Alonso, Manrique, Martinez and Nines., (2011).

Study Recommendations and Suggestions:

Based on what was mentioned in the study and in light of the researcher's findings throughout this

study, the following recommendations are made:

- Preparing schools to use innovations in educational technology such as ART in order to improve students' skills especially those with learning disabilities in various subjects.
 - Developing educational halls called "Computer Labs" existed in schools to meet the needs of students with learning disabilities
 - Holding workshops and training courses for teachers in both theoretical and practical dimensions of ART in order to prepare faculty members to handle this technique.
 - Supporting curriculum with appendices for each subject using ART. In doing so, the researcher aims at having a perfect private appendix based on views of specialists among workers from various educational fields.
 - Approving a curriculum about innovations of education techniques such as ART in universities. The researcher sees that there are no courses related to these innovations in higher education.
 - Employing ART by the faculty to increase the academic achievement among students with learning disabilities in Mathematics, thus the current study has proved the progress in these students' achievement in Mathematics.
 - Directing students by the faculty to use ART and notifying them of this technique's role in increasing their academic achievement.
- Finally, in light of the researcher's findings in the current study, which demonstrates positive results of using ART in increasing the academic achievement of students with learning disabilities in Mathematics, the researcher suggests conducting further research and studies on this technique as the following:
- Conducting further studies to determine the effectiveness of using ART on increasing the academic achievement of students with learning disabilities in courses other than mathematics.
 - Carrying out additional studies to investigate the efficiency of ART on increasing the level academic of students with learning disabilities in educational stages other than the primary stage, for which the current study was allocated.

- Doing another research to find out the ability of ART in increasing the acceptance of students with learning disabilities and ordinary students for the educational process in addition to their willingness to study. The researcher sees that this will extensively improve the educational process.
- Disseminating the current study experience in other geographical regions in the Kingdom, and draw conclusions based on these studies about the role of the geographical area in increasing the effectiveness of using this technique by comparing its results with the results of subsequent studies. Moreover, a comprehensive view of the effectiveness of using ART officially in all schools of the Kingdom can be emerged through this procedure.

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