

Research Article

The Impact of Augmented Reality Technology on Acquiring Temporal Concepts for Second-grade MIDDLE School Students in Mathematics

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Abstract

The aim of the research is to identify: (The Effect of Augmented Reality Technology on the Acquisition of Temporal Concepts among Second-Year Intermediate Female Students in Mathematics). To achieve the research objective, the researcher developed a null hypothesis. The researcher used an experimental design that included two groups: an experimental group and a control group. The research sample included 66 second-year intermediate female students, with the experimental group comprising 32 students, while the control group comprised 34 students. The researcher worked to achieve balance between the two groups in terms of variables such as chronological age (measured in months), intelligence level, parental achievement, previous year's mathematics grades, and last year's overall average, in addition to the selection of temporal concepts. The researcher then applied the post-test of temporal concepts. When the data were statistically processed using a t-test for two independent samples, the results showed a statistically significant difference between the average scores of the post-test of temporal concepts for students in the experimental group, who studied using the augmented reality strategy, and students in the control group, who used the traditional method in their studies.

Keywords

Augmented, Reality, Concepts for, Second, Graders, Mathematics

1. Introduction

The integration of educational technology into the educational process is of paramount importance, given its role in all processes, including assessment, intellectual interaction, and application between teachers and the learning environment. This technology is an essential element of education [23].

Augmented reality technology enhances education by combining real-world elements with digital landmarks, improving learning and increasing student motivation. [4].

Augmented reality technology is an evolution of virtual

reality technology, modifying real-world situations by adding digital elements to enhance student understanding. These elements include tools such as cameras to capture landmarks, icons to identify landmarks, and digital content used to store and process information. When images are captured, digital landmarks can track the objects in question.

Augmented reality technology is a powerful tool that allows students to experience and explore the learning environment. It enhances educational content by presenting it in a

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variety of ways, such as books, presentations, and learning media, contributing to the delivery of rich and diverse information. This technology also allows for the use of multiple elements, such as videos, still and moving animations, to meet students' individual needs. [22]

1.1. The Research Problem

The world is currently witnessing numerous developments in the field of educational technology, but these developments are not proceeding at the desired pace, significantly impacting the educational process. Modern technologies adopted to keep pace with this rapid advance in science and technology require continuous updating of curricula and educational practices.

Integrating modern technology into the educational process is essential, given its importance in curriculum development. Educational institutions around the world have shown great interest in teaching using modern applications and training in their use in the educational process. Most Arab countries have begun to take this approach, focusing on developing curricula at all educational levels, which also requires developing teachers' skills.

There is no doubt that the quality of education is closely linked to providing learning environments suitable for the use of technology, which contributes to improving educational resources for teachers. Therefore, relying on technology in education is vital to achieving desired educational goals.

Teaching educational curricula is a fundamental factor contributing to the development of society. We must teach students how to think, rather than simply memorize information. A deep understanding of the curriculum is essential to enable them to face the challenges of everyday life. Therefore, teachers must employ innovative teaching strategies that stimulate students' thinking. [4]

Education is one of the most important fields in any country, playing a vital role in shaping a person's character. However, the educational process in Iraq still relies heavily on rote learning, limiting teachers' ability to effectively deliver knowledge. I spoke with some middle school mathematics teachers and found that students struggled to grasp the subject. This is due to their reliance on memorization rather than comprehension, which negatively impacts their learning experience.

Societies face significant challenges in absorbing cognitive developments due to the increasing application of technology. Undoubtedly, the introduction of modern technology has imposed continuous development on educational systems to keep pace with these rapid changes. Research has also shown declining levels of academic achievement, underscoring the importance of using technology as a means to enhance students' learning processes, especially in the upper grades. Therefore, augmented technology can be considered an essential tool for modernizing education.

This fact is clearly shown by a study conducted by the re-

searcher: He conducted a survey of the opinions of a group of male and female teachers in middle and secondary schools. A closed questionnaire was distributed to (30) male and female teachers in schools affiliated with the General Directorate of Education in Nineveh, and the results were as follows:

- 1) (90%) of teachers, male and female, have not mastered the use of e-learning in teaching.
- 2) (100%) of teachers did not have accurate information about technology that enhances education.
- 3) (80%) of teachers' opinions indicated that there was a decline in the level of achievement of female students in mathematics.
- 4) (50%) of teachers' opinions indicate that the traditional method (memorization and indoctrination) used in teaching is limited to transmitting facts and information.
- 5) (80%) of teachers have no prior knowledge of learning processes.
- 6) (90%) of teachers' opinions indicate that female students still want to use e-learning.

The results of the questionnaire indicate a decline in the level of achievement of female students.

1.2. The Importance of Research

Teaching science is not limited to merely conveying information; it also requires an understanding of the nature and methods of science. This approach to teaching mathematics requires the use of multiple strategies appropriate to the medium's content. [20]

Thinking skills are essential in science education. Students must be taught how to think critically rather than simply memorize academic information. This helps them assimilate information and apply it to their practical lives, enhancing their understanding of scientific processes and avoiding errors. Education is a comprehensive social process, encompassing all factors that influence an individual's life and contribute to shaping and developing their personality across mental, social, spiritual, and psychological dimensions.

Students must be able to absorb intermediate material and utilize it in practical life applications. Increasing knowledge does not simply mean accumulating information; it must also include the ability to engage with technological applications. The real challenge for educators in this field is to teach individuals how to think critically and solve problems, rather than simply training them to memorize.

It is clear from this that mathematics teachers must focus on carefully planned educational activities, as the development of mathematics curricula depends on sound scientific processes. This is essential for preparing a generation capable of interacting with contemporary issues and making appropriate decisions to deal with natural and intermediate phenomena in society. Therefore, intermediate processes must be taken into account when developing curricula. [19]

Scientific processes are divided into two categories: basic processes that include observation, measurement, documen-

tation, inference, reasoning, prediction, use of numbers, and employment of temporal and spatial dimensions, and integrative processes that include data interpretation, operational definitions, control of variables, hypothesis formulation, and experimentation.

Therefore, it is necessary to focus on these processes in the educational process and train students to acquire the necessary skills, as this is considered one of the most important goals of secondary education.

The primary objectives of school education are among the most important factors contributing to shaping generations capable of sound thinking. There is a saying that educational and pedagogical programs should focus on developing mental processes rather than simply memorizing information. It is no longer sufficient to train students to memorize large quantities of information; the goal should be to achieve a deep understanding of the subject matter and enable them to apply what they have learned in their practical lives.

Enhancing knowledge is not limited to absorbing information; it also requires the ability to deal with technological applications and mediums. Therefore, the real challenge for educators in this field is to teach individuals how to think critically and solve problems, rather than simply training them to retrieve information. [20]

It is important for science teachers, like biology teachers, to pay special attention to developing students' intermediate thinking skills through planned educational activities. Developing curricula that focus on intermediate processes contributes to the development of a generation capable of interacting with complex issues and making appropriate decisions in the face of natural and intermediate phenomena in society. Therefore, intermediate processes must be considered in all aspects of education.

Practicing intermediate operations is a fundamental goal in science education at all grade levels. Teachers are responsible for helping students use basic intermediate and integrative operations, reinforcing the need to develop intermediate skills related to science. These operations help students consolidate their learning through experience, as students begin with simple ideas that combine to form new, more complex ideas.

All of these ideas contribute to enabling students to research and make decisions independently, which enhances their ability to solve problems. [19]

- 1) The importance of the research is evident in the following points.

This new curriculum supports students in learning through non-traditional teaching methods. [17]

- 2)
- 3) Researchers in the field of educational technology encourage the use of augmented technology in the educational process.
- 4) One of the modern trends in e-learning is presented, which is based on the use of enhanced technology.
- 5) This field opens new horizons for future studies using augmented reality.

- 6) Highlights the importance of using augmented reality to provide an educational environment that contributes to enhancing students' learning, as they can learn through augmented reality anywhere, which enhances their self-capabilities and provides immediate feedback.

- 7) This study combines theory and practical application, as the content is addressed using the latest augmented reality technologies.

Third: Research objective:

The research aims to identify:

Augmented reality technology in acquiring temporal concepts Second grade math students have effective scientific processes.

1.3. Research Hypothesis

hypothesis was formulated.:

“There is no statistically significant difference, at the level of (0.05), between the average scores of the experimental group students who studied according to the augmented reality strategy and the average scores of the control group students who studied according to the usual method in the post-selection of acquiring temporal concepts.”

1.4. Research Limits

- 1) Human Limits: The research sample is limited to second-year middle school students at Al-Shorouk Girls' Secondary School, affiliated with the General Directorate of Education in Nineveh, for the academic year 2024-2025.
- 2) Cognitive boundaries: The study includes five chapters from the mathematics book for the second intermediate grade.
- 3) Time frame: academic year 2021-2022.
- 4) Spatial boundaries: One of the government primary schools affiliated with the General Directorate of Education in Nineveh.

1.5. Definition of Terms

Below is a definition of the terms used in the research:

First: Effect

Known by:

1. Al-Dulaim (2005) defined it as “the amount of change that occurs in a dependent variable as a result of the influence of the independent variable.” [18]

Operational definition: It is the change that occurs in the achievement of second-grade middle school female students (research sample) after using augmented reality technology in mathematics.

1.6. Augmented Reality Technology

It was defined by Abdullah (2022) as “a method of displaying information directly or indirectly about actual ele-

ments in the real world, where these elements are enhanced by sensory inputs generated using computers or mobile devices such as smartphones or tablets, simulating the real world.” [16]

Operational definition: The researcher uses augmented reality technology in teaching second-grade female students (students in the experimental group) mathematics subjects.

2. Theoretical Background and Previous Studies

Axis One: Theoretical Background

First: Augmented reality technology

This term is a modern one that has emerged in various fields, including technological projects applied in the educational process. The term "augmented technology" has been used as one of the most prominent terms in discussions translated into Arabic. Technology projects are implemented in practical applications, allowing students to interact and better understand the information presented.

Augmented technology is considered valuable in expanding technological knowledge. The term "augmented reality" emerged in the 1950s. At that time, Heiling Morton, a pioneer in the art of cinema, believed that cinema should be able to engage viewers' attention with what was happening on the screen. Models of augmented reality were introduced in the 1960s, using projection through screens to show dimensions. Sutherland, who developed this field, developed this concept. [15]

When asked to find a suitable alternative to classic painting graphics for use as a substitute for large advertising graphics, Thomas Bruce invented an augmented reality game in 2000, considered one of the first applications in the field of semantic computing. In 2007, augmented reality technology was developed, and in 2008, Wikitod released medical applications based on this technology. Gartner also reported that augmented reality was among the top 10 technologies deployed in 2008 [10].

Sarubon (2016) also points out that “integrating digital books with augmented reality technologies is an effective way to enhance learning, as students can benefit from the augmented book by using their mobile phone camera to access digital content, which may include animation or interactive elements, enriching their learning experience.”

On the other hand, Ibrahim (2017) notes that augmented reality technology relies on linking real-world elements with appropriate virtual elements, which helps enhance memory by providing information about the location or educational topic. Augmented reality software also relies on using a mobile phone or computer camera to view and analyze real-world situations, depending on the program's requirements for integrating virtual elements.

Al-Ashish (2016) explained the points of agreement and difference between 2-2-augmented reality and virtual reality

as follows:

Technology: Both technologies rely on technology to improve user experience.

Upgrade: Technology companies strive to continuously develop applications, which leads to continuous improvements and the release of more products that support these technologies for users.

Medicine: Augmented reality can revolutionize the medical field, as it has already been used in some psychological conditions such as post-traumatic stress disorder (PTSD) by performing remote surgeries.

Technical requirements: Augmented reality requires inexpensive hardware such as cameras that can be used on any smartphone, while virtual reality requires expensive hardware that completely isolates the user from the real world.

Ibrahim (2016) and Al-Tamimi (2018) (235-300) identified the following -3-2: characteristics of technology in augmented reality

- 1) It is interacted with.
- 2) Recognize items in the real world.
- 3) Enhances the sense of the real world.
- 4) The technology is also wearable.

The main characteristics can be summarized as follows:

- 1) 3D Visualization: Provides an immersive learning environment by presenting 3D content, which greatly enhances the learning experience.
- 2) Ease of movement: Smart devices enable augmented reality to be displayed in learning environments, making it easier to navigate and interact with content.
- 3) Accessibility: Provides access to a large number of live resources in enhanced virtual environments, allowing learners to access information anytime, anywhere.
- 4) Interaction: This technology enhances student interaction with teachers, which contributes to improving the educational process.
- 5) Flexibility: Students and teachers can access content from anywhere, providing flexibility in learning.
- 6) Ease of use: Augmented reality technology does not require any complex requirements, making it easy to use.
- 7) Collaboration: This technology allows students to collaborate with each other, which enhances social interaction and contributes to an improved learning experience.

2.1. Augmented Reality Features

- 1) Providing an encouraging learning environment.
- 2) Enhancing cooperative learning strategies among students.
- 3) Provide engaging support for content that interests students and supports learning theories.
- 4) Applying interaction with students using multimedia in the learning process [12].

2.2. Obstacles to Using Augmented Reality Technology

There are a number of obstacles facing the application of augmented reality technology and limiting its use, the most prominent of which are:

- 1) Lack of experts specialized in augmented reality applications.
- 2) Schools lack sufficient conviction in the importance of this technology in education, which leads to students not interacting well.
- 3) Lack of financial resources needed to implement projects based on augmented reality technology.
- 4) There are technical problems related to the digital content not being properly compatible with the devices used.
- 5) Some students believe that augmented reality technology is ineffective [13].



Figure 1. Shows the quick response based on images and labels.

2.3. Augmented Reality Applications and Programs

Applications and programs that use augmented reality technology in education include:

- 1) UniteAR and Zappar: These two applications are used in the current research, and we will discuss their use when presenting augmented reality learning models.
- 2) Anatomy 4D: This app is an interactive tool for human anatomy, displaying all body systems in 3D. However, it does not specify spatial depth between organs, which may hinder students' understanding of the physiological processes occurring within the body [9].

3) Dynamic Anatomy App: This app, used in a study by Bogomolova and colleagues (2020), is used in the Department of Anatomy at the Medical Innovation Center at Leiden University. The app provides a dynamic model of bone anatomy dimensions.

4) Augmented Medicine App: According to a study by Brown and colleagues (2020: 1), this app is used by medical students to develop their organ dissection skills after kidney and pancreas transplantation.

Classification of rapid responses in augmented reality learning

Quick responses are classified according to the evidence used to connect the user to the augmented reality content. According to Alia's study (2018), these responses can be divided into the following categories:

1) Quick response based on images and captions

This response relies on the use of symbolic forms and signs available in books, cards, or content that can be scanned using a smartphone camera or mobile device. This content can be fixed or variable. [14].

Quick response using Zap code[21]

QR code can be used to link to multiple websites across the internet, by scanning it with the camera of a smartphone or mobile device.

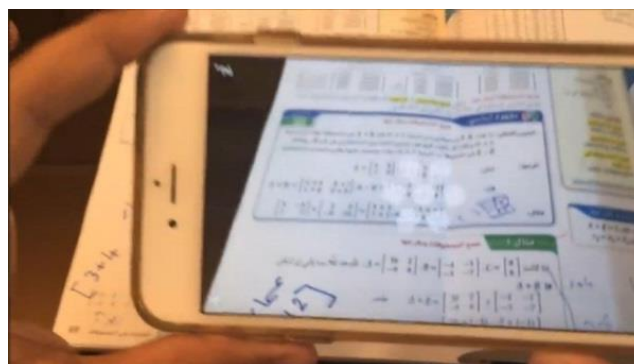


Figure 2. Shows a quick response based on Zap code.

2) Icon-based quick response

These icons consist of various, nonspecific shapes, representing a specific object that cannot be identified by touch or camera. These icons are used to read information and visualize the integration in different dimensions.



Figure 3. Instant response based on icons.

In this study, the researcher relied on quick answers based on images, tags, and codes, as these elements correspond to selected chapters of the biology textbook. These types of tools are suitable for use in augmented reality, making them easier for students to utilize.

2.4. Augmented Reality Modes

Augmented reality technology is divided into two forms:

- 1) Location-Based: This type relies on GPS technology, allowing students to use different digital elements as they move between various physical elements.
- 2) Vision - based: This type is linked to mobile device camera technology, where students can learn about a specific physical reality that is displayed on the screen in the form of various digital elements.

Augmented reality technologies are classified into several categories, as follows:

- 1) Discovery - based learning: Augmented reality applications can be used to help students discover information through digital elements available in the real world.
- 2) Modeling: Equations are modeled for students to provide interactive feedback on some examples.
- 3) Augmented Reality Books: These books use special screens that display content enhanced with digital media, providing students with an interactive learning experience. [15]
- 4) Among the books used in the current research:

Augmented reality books based on 3D graphics:

The use of multi-projection technology in the educational process effectively contributes to overcoming the challenges faced by teachers and students. Animations, video clips, and other media help attract students' attention. Research results (Nabil, Jad Azm, 2006, pp. 27-29) demonstrated the effectiveness of the multi-projection program in clarifying some intermediate concepts in a science field for students of the College of Education in the Sultanate of Oman. The students demonstrated a high level of mastery of the educational content.

Video-based augmented reality books:

Educational video is considered one of the most effective tools in the field of education, as it contributes to raising the efficiency of students' academic achievement. There has been significant development in the production of education-

al materials, which helps students control the presentation of content and the ability to rewatch lessons more than once. Video also contributes to achieving the principle of self-learning by allowing students to adjust the presentation speed according to their needs. Some studies indicate the importance of using interactive video in various curricula. Hartley and Wang (2003) confirm that educational video has the ability to enhance educational situations and increase students' interaction with the educational content. [1]

Augmented reality components:

Augmented reality technology relies on a range of components, including displays for computers and mobile devices. These components can also include technologies such as virtual reality.

Portable screens: These are computers or other devices with a screen that the user can easily carry, as shown in Figure 4.



Figure 4. Portable screen.

Head-mounted displays are devices worn on the head and used as part of a display system installed in front of the eyes, as shown in Figure 5.



Figure 5. Head-mounted display.

Main devices used for data entry in augmented reality

A. Smartphones: Mobile devices equipped with digital cameras are used to display 3D videos. These devices rely on radio frequency tracking technologies, providing varying levels of accuracy. (Saeedi, 2009: 21)



Figure 6. Smartphones.

Computers: These are primarily used to analyze numerical data only. There are four main ways of interacting in augmented reality applications, namely: interactive applications, hybrid interactive applications, and multi-drop interactive applications, as shown in Figure 7.



Figure 7. Computers.

2.5. The Importance of Using Augmented Reality in Academic Achievement

The use of augmented reality in the educational process aims to help students process information more effectively, providing them with an interactive learning experience that surpasses what traditional technologies can offer. According to previous studies, the importance of augmented reality can be summarized in the following points:

- 1) Enhancing the positive attitude of students who participate in immersive learning experiences provided by augmented reality technologies.
- 2) Using augmented reality technologies to develop critical thinking, which contributes to improving academic achievement.

- 3) Providing students with the opportunity to learn in formal and informal environments.
- 4) Providing interactive educational scenarios that enhance augmented reality applications.
- 5) Presenting new concepts in an innovative way that contributes to a better understanding of information.

It is believed that one of the reasons for using augmented reality in the educational process is its importance in developing our schools to keep pace with changes that help increase teaching efficiency. Teachers can deliver lessons in a manner that is compatible with modern technologies, which contributes to improving the learning experience. [7]

The benefits of augmented reality include:

- 1) Motivate students to enhance critical thinking skills.
- 2) Help students discover accurate information.
- 3) Monitoring how students absorb educational content and how quickly they understand it.
- 4) Enabling students to retain information for a longer period of time. [6].

Second: Temporal concepts

Research indicates that the importance of augmented reality in the educational process extends not only to students but also to teachers. In addition, augmented reality helps bridge the gap between theory and practice.

Second: Temporal concepts

Time is one of the fundamental dimensions of the universe, and the concepts of past, present, and future are important mental concepts for constructing experiences. We live in a constantly changing present, and our experience of the past, present, and future continues to transform.

Understanding the abstract concept of time is not easy. The concept of time depends on acquiring many time-related abilities, such as understanding time, the ability to distinguish between the past, present, and future, and thinking about the sequence of events [8].

Types of temporal concepts

Concepts of time such as Islamic wars.

Concepts of place such as the Battle of Badr.

Physical concepts such as planets. [12]

The importance of time concepts in the study of mathematics

To understand the content of mathematics, without which the process of teaching and learning mathematical studies loses many of its objectives.

Concept development is a crucial factor in the process of understanding the meaning of mathematics texts.

Uses of time concepts in the study of mathematics[4]

Understanding a particular word over time, such as (Arabization).

Perception of a particular image over time, such as (mathematicians).

Previous studies:

First axis: Studies that dealt with augmented reality technology

Study (Heba, 2022): The study aims to identify: the effect

of augmented reality technology on the achievement of fourth-grade science students in the subject of biology and their scientific processes.

To achieve this goal, the researcher seeks to test the following two hypotheses:

There is no statistically significant difference at the level (0.05) between the average scores of the experimental group students who study using augmented reality technology and the average scores of the control group students who study using the traditional method in the achievement test.

There is no statistically significant difference at the level (0.05) between the average scores of the experimental group students who study using augmented reality technology and the average scores of the control group students who study using the traditional method in the science operations test.

The research tools were prepared, including an achievement test and a science processes test. The researcher developed an achievement test covering the first five chapters of the biology textbook for the fourth grade science. The final test included (50) objective multiple-choice test items with four alternatives. The face validity and content validity of this tool were verified. As for the science processes test, it included (40) test items of the same type, covering the following processes: observation, classification, inference, deduction, prediction, operational definition, variable control, and interpretation. The face validity of this tool was also verified. The psychometric properties of both tests were calculated. The data were uploaded to SPSS (version 22) and statistically processed using the t- test for two equal independent samples, in addition to using the Kuder-Richard equation - 20, the split-half method, Pearson's correlation coefficient, standard deviation, difficulty coefficient, discrimination coefficient for items, and the effectiveness of alternatives for objective items. The results showed differences between the experimental group taught using augmented reality technology and the control group taught using the traditional method.

Axis II: Studies that addressed temporal concepts

Since the researcher did not find any Arab study that dealt with the study of time concepts, the researcher was forced to undertake a comparative study.

Study:

A new model of the development of time concepts posits

fundamental changes in how children think about time during the first years of life. This model suggests a shift from an event-based understanding of time to an independent understanding of time. In early development, young children have difficulty thinking about temporal locations independently of the events occurring at those locations. As they grow older, children begin to develop a better understanding of the distinction between past, present, and future, representing time as a straight, one-way line. The model posits that although two- and three-year-olds may categorize events based on whether they occur in the past or future, they may not realize that an event's location in time (future or past) changes over time and depends on temporal perspective. By the age of four to five, children begin to understand how causality operates in time, enabling them to perceive systematic relationships between different temporal locations, which forms the basis for the acquisition of traditional clock and calendar systems [11].

Benefits of previous studies

Help formulate the hypotheses and objectives of the current research.

Testing the appropriate experimental design and equivalence between the two research groups.

Preparing the search tool.

Benefit from the statistical methods used in previous studies.

Preparing special model teaching plans.

Helping the researcher to access sources related to the current research.

The results of this study are useful in interpreting the results of the current research.

3. Research methodology and procedures

First: Research methodology and procedures

The researcher chose the experimental design, which included two equivalent groups: one experimental (teaching strategy according to augmented reality technology), and the other control (the traditional method), as shown in Table 1 below:

Table 1. Experimental design of the research.

Search tool	Dependent variable	Independent variable	The group
Post-test of time concepts	Acquiring time concepts	Teaching with Augmented Reality Technology	Experimental
		The usual way	The officer

*Second: The research community and its sample**Research community*

The research community included second-grade intermediate female students who studied in government intermediate schools in Nineveh Governorate, General Directorate of Education in Nineveh for the academic year (2024-2025).

3.1. Research Sample

Student Sample: Section (A) was randomly selected to be

the experimental group that will receive education using augmented reality technology, while Section (C) represents the control group that will be taught using the traditional method. The number of sample members in the two groups was (66) male and female students, as the experimental group includes (32) female students from Section (A) and (34) female students from Section (C). The researcher did not exclude any male or female student from the two groups, as no cases of failure were recorded among them, as shown in [Table 2](#).

Table 2. Sample research.

Total number	Number of students in each department	The branch	The row	The school	The group
66	32	A	Second intermediate	Al-Shorouk Intermediate School For girls	Experimental
	34	C			The officer

Third: Equivalence of the two research groups

“The researcher worked to investigate the equivalence between the groups for the research, which may be addressed, as the two groups must be equivalent as much as possible in all factors.” (Al-Kaim, 2005, p. 438)

The aim is to ensure the equivalence of all variables that affect the research results. The variables were controlled:

Chronological age in months.

Final grades for mathematics for the previous year.

The overall average of students' grades for the first grade

is average for the previous year.

Intelligence test.

Pre-test of time concepts.

Parents' academic achievement.

Mothers' educational attainment.

3.2. Chronological Age in Months

T-test results for the chronological age of the students of the two groups, calculated in months, [Table 3](#).

Table 3. Chronological age in months.

Significance level at (0.05)	Lost value Tabular	The calculated	Standard deviation	Broker account	Number	The group
equivalent	1,998	0.07	533,769	1,676,562	32	Experimental
			884,628	1,675,294	34	The officer

Table 4. Grades of the subject of mathematics.

Significance level at (0.05)	Lost value Tabular	The calculated	Standard deviation	Broker account	Number	The group
equal	1,998	0.213	996,263	713,125	32	Experimental
			777,250	707,941	34	The officer

The overall average of the grades of fourth-grade middle school students for the previous year
The overall average of the grades of second-grade female students for the previous year, [Table 5](#).

Table 5. Last year's grades.

Significance level at (0.05)	Lost value		Standard deviation	Broker account	Number	The group
	Tabular	The calculated				
equivalent	1,998	0.184	866,145	671,156	32	Experimental
			840,298	677,294	34	The officer

Intelligence test

Value for intelligence scores for the two research groups [Table 6](#).

Table 6. IQ test.

Significance level at (0.05)	Lost value		Standard deviation	Broker account	Number	The group
	Tabular	The calculated				
equivalent	1,998	0.59	699,308	327,500	32	Experimental
			572,459	336,765	34	The officer

3.3. Pretest of Temporal Concepts

Test values for the pre-test for the two research groups [Table 7](#).

Table 7. The pre-test of time concepts.

Significance level at (0.05)	Lost value		Standard deviation	Broker account	Number	The group
	Tabular	The calculated				
equivalent	1,998	1,393	533,240	152,188	32	Experimental
			311,914	167,059	34	The officer

Parents' academic achievement

Special results Chi - square for parents' level of achievement [Table 8](#).

Table 8. Academic achievement of parents.

Significance	Chi-square value		Institute, university and higher education	Intermediate or secondary school	Elementary and below	The group
	Tabular	The calculated				
equivalent	99.5	219	12	14	6	Experimental

Significance	Chi-square value		Institute, university and higher education	Intermediate or secondary school	Elementary and below	The group
	Tabular	The calculated				
	(2) (0.05)		14	15	5	The officer

Mothers' educational attainment

The result of the chi-square for the level of mothers' achievement, [Table 9](#).

Table 9. Academic achievement of mothers.

Significance	Chi-square value		Institute, university and higher education	Intermediate or secondary school	Elementary and below	The group
	Tabular	The calculated				
equal	99.5	1,623	7	15	10	Experimental
	(2) (0.05)		8	11	15	The officer

Fourth: Control of internal variables that affect experimental design.

The researcher tried as much as possible to avoid the impact of a number of internal variables on the course of the experiment, and the experiment was not exposed to any circumstance that would hinder its progress and affect the dependent variable in addition to "The effect of the independent variable."

Fifth: Research requirements

Determining the scientific subjects: The scientific subject that will be taught to the students during the trial period has been determined based on the topics of the mathematics curriculum that is scheduled to be taught to the second middle grade for the academic year (2024-2025).

Formulating behavioral objectives: After the researcher identified the scientific topics that would be taught to the members of the two research groups during the experimental period included in the curriculum for the second intermediate grade for the academic year (2024-2025), 49 behavioral objectives were formulated for them, distributed across the first four levels in the cognitive field of Bloom's taxonomy, which are (understanding, knowledge, analysis, application).

Preparing teaching plans: (7) were prepared for the experimental group and the same for the control group. The plans for the experimental group were organized to use the transfer learning strategy and the control group according to the usual method..

Sixth: Search tool

Preparing a test to measure time concepts for both research groups is a basic requirement for the study. This is due to the lack of a ready-made instrument appropriate for

the current research topic in second-grade mathematics. This requires the researcher to develop a specific instrument to measure these time concepts.

The definition of temporal concepts

It is considered one of the The main requirements for research into measuring temporal concepts are that the temporal concepts must be identified and determined by the researcher, which are (30) concepts, in order to be the focus for constructing the conceptual test.

Test validity

Validity in a test refers to its ability to measure what it was designed to measure [2]. The goal is to ensure that the test achieves its stated objectives. The researcher relied on face validity, which involves conducting a preliminary examination of the scale to ensure its accuracy in measuring what it is supposed to measure. This type of validity begins with the scale items being read by specialists. To achieve this, the researcher presented the test to a group of judges in mathematics teaching methods to obtain their opinions on the test's validity and safety. Based on their comments and suggestions, modifications were made to some items to enhance face validity.

Correction criteria:

In order to correct the answers to the test paragraphs, the researcher prepared the model answers to the paragraphs and the correction depended on a sensitivity of (0.1) for each of the test paragraphs.

is given one mark, while an incorrect answer or an omitted or abandoned answer is given a mark of (zero), and the same applies when choosing more than one alternative.

Exploratory sample test

The test was administered to a representative sample of the research, as it met its specifications. The sample consisted of 100 female students from the second intermediate grade at Akbiba High School. After administering the test, it was found that the time required to complete all the test items was 40 minutes. After correcting the answers, the scores were arranged in descending order, and then a ratio of 50% was adopted for the upper group and 50% for the lower group. Values reflecting the difficulty and discriminatory power of the items were also extracted, as follows:

Difficulty of test items

After the difficulty factor has been calculated for each of the selected items, it was found to be between (0.37) and (0.61). The researcher concludes from this that all the test items are considered acceptable and valid for application. Sources indicate that an effective test is one that includes items whose difficulty ranges between (0.20/0.80) [5].

Thus, the items included in the test are considered acceptable in terms of their difficulty.

Distinguish test paragraphs:

It means the ability of all the test paragraphs to distinguish between students with higher levels and students with lower levels with regard to the ability that the test measures. The researcher found that it ranges between (0.30) and (0.59). If the discrimination power of the paragraphs is (0.30) or more, then it is considered good.

Test reliability

Reliability means that a test yields the same results when repeated on the same individuals under the same conditions (Hussein, 2019, p. 41). Reliability also refers to the stability and consistency of the sample members' scores across the different test items. Therefore, the researcher calculated the test's reliability using the Kuder-Richardson-20 equation and found that the reliability value was 0.82, which is considered

a good reliability coefficient. Tests are considered good if their reliability coefficient is 0.76 or greater [11].

Accordingly, all test items were retained, and it was ready for application to the research sample.

Statistical methods

- 1) The t - test showed equivalence in age in the mathematics score and in the intelligence test score [3].
- 2) Paragraph difficulty equation, to measure the strength of the paragraph.
- 3) Paragraph discrimination equation.
- 4) Richard equation Dson (20) to measure the reliability of the test.
- 5) Chi-square, equivalence of educational level of fathers and mothers.

4. Presentation and Discussion of the Results

Presentation and discussion of results

Results related to the null hypothesis:

The results indicate that there are no statistically significant differences at the level of (0.05) between the average scores of acquiring temporal concepts among the students of the experimental group who studied using the augmented reality technology strategy and the students of the control group who studied using the traditional method. To verify this hypothesis, the arithmetic mean and standard deviation of the scores were calculated, then the t- test was applied for two independent samples, and the results were listed in Table 10. Table 10 shows the results of the t -test for the arithmetic mean and standard deviation of the experimental and control groups in acquiring temporal concepts.

Table 10. Test results of the arithmetic mean standard deviation of the experimental and control groups.

Significance level at (0.05)	Lost value Tabular	The calculated	Standard deviation	Broker account	Number	The group
Statistically significant in favor of the experimental	1,998	4,780	420,433	225,312	32	Experimental
			297,778	182,647	34	The officer

By reviewing the table above, it is clear that the calculated value of (t) reached (4.780), which is higher than the tabular value of (1.988) at a significance level of (0.05) and (2) degrees of freedom. Therefore, the alternative hypothesis is accepted, which indicates the presence of a statistically significant difference at the (0.05) level between the average scores of acquiring temporal concepts among students in the

experimental group who were taught according to the transfer learning strategy, and students in the control group who were taught using the traditional method. The researcher attributes this result to the fact that the transfer learning strategy contributed effectively to enhancing students' achievements, which helped them better understand and acquire temporal concepts.

5. Conclusions, Recommendations and Suggestions

First: Conclusions

The effectiveness of augmented reality technology strategy in acquiring temporal concepts among second-grade middle school female students

The effectiveness of augmented reality technology strategy in retaining mathematical information among second-grade middle school female students.

Second: Recommendations

directorates, through preparation and training, hold training courses for teachers using the transformative learning strategy in teaching mathematics.

Working on training teachers on how to use augmented reality technology strategy in teaching mathematics subjects through training courses.

Third: Proposals

The researcher proposed several proposals, the most important of which are:

The effectiveness of augmented reality technology strategy in developing temporal concepts among second-grade middle school female students.

The effectiveness of the augmented reality technology strategy in acquiring temporal concepts among second-year middle school female students.

Abbreviations

M The Academic Title of Teacher

Author Contributions

Ammar Awad Saleh is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflicts of interest.

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