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The Effectiveness of Integrating Augmented Reality in Education to Stimulate Reflective Thinking among University Students.

By

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Abstract
The present research is an experiment in the context of Kuwait's higher education, which is based on augmented reality (AR) technology. The main objective is to investigate the efficacy of AR-based learning on reflective thinking as essential indicators of students" learning and achievement. The research is based on a qualitative methodology (pre and post-test) using reflective thinking scales for the quantitative approach. The experiment was implemented on a purposive sample of 30 students in Training courses in the Applied Education Art Department and 30 from the Education College-Applicable Education Art Department at Kuwait University. The research results indicated that students in the AR condition significantly improved their understanding of artwork and showed more significant gains than those in the non-AR condition. Student interviews also revealed that the AR served as a valuable learning platform by enabling students to visualise artefact design details, recognise and make sense of short information, and gain a more accurate understanding of the artwork learning.

Keywords: Augmented Reality, art education, reflective thinking, artefact

Introduction

Universities acknowledge that the current Industrial Revolution has familiarised augmented reality tools as a new technology in education. Augmented reality is a computer-generated optical effect in which virtual objects are superimposed onto the real-world surroundings displayed on the screen. Augmented reality technology can transmit information more effectively to the virtual world than the real world (Ginsburg et al. (2008) [1]. Usually, the augmented reality tools that will be used include cameras, computer webcams, and special glasses. The display technique incorporates three-dimensional objects' characteristics, including animation, audio, and video (Van-Krevelen et al. (2010) [2]. This feature allows the smartphone to scan the camera towards the focal point of the intended image, even when directed at a flat surface. The potential presence of augmented reality technology in education must be identified to enable it to benefit education truly. In addition, it is necessary to recognise elements of form and content to make learning artwork more relevant and meaningful in education. The augmented reality technology study suggests reforms to the country's education system, particularly in artistic work learning. Augmented reality can improve students' interest and inspiration to acquire artistic work (Azuma et al. (2001) [3].

Chen, Chen, Huang, and Hsu (2010). [4] indicated that the applications of augmented reality (AR) techniques were limited to colossal equipment, such as head-mounted displays or a whole suite of wearable devices. Today, AR hardware and development tools have matured and become flexible with the evolution of information technology, and even essential smartphones or tablets with camera devices can now be used for AR interaction.

Researchers Bitter and Corral (2014)[5] and (Botella et al.2011)[6] have found that augmented reality (AR) applications are becoming increasingly widespread, mainly through mobile learning devices for commercial, advertising, and educational purposes. AR techniques combine elements of the real-world environment with computer-generated imagery, providing interactive visualisations and simulations alongside traditional 2D content.

Specht et al., (2011)[7] have reported that the use of mobile-based AR apps in education has been proven to be more effective than the use of traditional textbooks and benefits students' learning motivation in the learning process. Besides, the features of presenting learning information, textual, video, audio, and three-dimensional learning contents together in real-time interaction might stimulate learners to learn abstract ideas more than only reading a text-based book. For example, Henderson, S., & Feiner, S. (2011)[8]. Adopted the problem learning strategy with the AR technique to supply students with an interactive interface and learning media for an outdoor landscape course activity.

Research Significant

1. College applied and fine arts students often struggle with art design vocabulary, where elements and principles represent the 'vocabulary' that defines the composition's structure.
2. The first step in constructing successful visual compositions comprehends the elements and principles of design used in all visual design fields, which is the foundation of all intentional visual design strategies [9&10].
3. A firm grasp of art design vocabulary is essential for understanding art design principles. Current teaching methods often rely on rote memorisation, making learning dull and unengaging.
4. Educators frequently indicate information without aligning it with students' interests and abilities, which detracts from an inspiring learning atmosphere.
5. Selecting less effective teaching methods is one of the main factors contributing to weak design vocabulary mastery. This is due to the selection of teaching methods that are less engaging and varied.
6. Students must be exposed to various techniques for mastering art design vocabulary to acquire as much vocabulary as possible to construct artwork design [11].
7. This indicates that studies with augmented reality have been widely conducted in artwork design learning.

Terminology

1. Mehler-Bicher et al. [12] defined augmented reality as a real-world environment enhanced by the dynamic overlay of coherent, location-based, or context-sensitive virtual information.” [13].
2. Nincarean et al. [14] and [15] define augmented reality applications as integrating virtual objects into real scenes. They argued that augmented reality applications must have three essential characteristics:

(1) The combination of virtual and real objects in a real environment
(2) An interactive study in a real-time environment
(3) Consistency between the real and virtual objects.

Theoretical Background Augmented reality

A study emphasises that augmented reality is divided into optical and video-based technologies. The difference between the two technologies is how the scene integrating the real and virtual worlds is viewed. In optical systems, the scene is represented in the real world via glasses, while in video-based technologies, the scene is represented on a monitor or mobile device screen [16].

Reflective thinking scale

This study, in which AR applications were implemented, aimed to identify the influence of AR activities on student candidates’ reflective thinking skills. The scale consists of 4 dimensions and 20 statements; the dimensions are as follows: “Normal activity”, “Conception, “reflection” and “critical reflection.

Perkowska-Klejman [17] reflection levels have been explained in the following table. In addition, the whole scale’s Cronbach's alpha value was calculated as (0.92). These item features are on a 5-point response scale (1 = disagree; 5 = strongly agree).

Description levels of reflections

Level of student’s reflexivity	Description of the level of reflection

Normal activity	Activity that is learnt through frequent, automatic use. "In professional practice, regular action occurs when a procedure is observed without significant thought about it." [18]
Conception	Thoughtful exercise of individuals in which they use their current knowledge and achieve comprehension of different topics or phenomena. In this case, there is an endeavour to understand the topic or concept. Most students begin at this level. Their artwork relies heavily on what the textbook or instructors explained.
Reflection	The exposition and assessment of assumptions about the content or method of problem-solving. At this level, students have a precise understanding and can relate it to personal experiences or make usable applications.
Critical reflection	This highest level of reflection indicates the transformation of a perspective. Instructors should not anticipate this level of reflection early or often while students invent their reflective skills. Students start by identifying their beliefs and accompanying hypotheses. Something (new information, new experiences) disrupts that assumption.

Methodology

Research design

- This study employed a quantitative approach, utilising a survey method with a questionnaire.
- Data analysis was conducted descriptively using measures such as frequency, percentage, mean, and standard deviation to assess the level of student Reflective thinking by the technique of augmented reality.

The study is a mixed approach in which qualitative and quantitative data are used concurrently. The study was organised according to pre-test and post-test research model with experiment.

Study sample

The study sample comprises 30 students from The Public Authority for Applied Education and Training (as a post-test) and 30 from the Education College—Art Education Department (as a Pre-test) [19].

The researchers used the random sampling method, which could help:

- Minimise bias,
- Ensure that the sample is a fair representation and
- Provide a solid foundation for statistical analysis.

Research Objectives

To study the impact of augmented reality on reflective thinking in students.

Procedures:

1. Design artwork educational materials using augmented reality applications.

2. Select a sample of university students in art education.
3. Conduct pre-and post-tests to measure reflective thinking.
4. Analyse the results using statistical tools (SPSS 25).

The experimental artwork covers the following areas:

1. Identify artwork students' knowledge of augmented reality technology.
2. Identifying artwork students' willingness for the regular activity, student Conception, reflection and critical reflection to use augmented reality Technology.

Research hypotheses:

After the researchers reviewed the literature and results of previous research and studies related to the research topic, it was appropriate to formulate the hypotheses as follows:

1. There is a statistically significant difference at the level ($0.05 \geq \alpha$) between the average scores of the experimental group students in the pre-and post-application of the achievement test toward the post-application.
2. There is a statistically significant difference at the level ($0.05 \geq \alpha$) between the average scores of the experimental group students in the pre-and post-application of the observation card toward the post-application.

Research Questions

Under the statistically significant differences of the level (≤ 0.05) at the average scores of the research sample in the pre-and post-applications of the augmented program , the following main questions are:

1. Are there statistically significant differences between the experimental group before and after applying the augmented program on the scale of innovative thinking skills for Normal activity dimensions skills?
2. Are there statistically significant differences between the group before and after applying the program on the scale of innovative thinking skills for the Perception dimensions?
3. Are there statistically significant differences between the group before and after applying the program on the scale of innovative thinking skills for the Reflection dimensions skills?
4. Are there statistically significant differences between the group before and after applying the program on the scale of innovative thinking skills for the critical Reflection dimensions skills?

Literature review

Alkhattabi [20] states that it is more accurate to think of AR applications as a concept rather than a type of technology. Furthermore, Alkhattabi indicates that AR does not substitute real objects by placing them into a real environment; instead, it has a supportive role in students' experiences and enables them to benefit from the real-life opportunities it provides.

Nincarean et al. [21] claim that augmented reality environments increase student-student and student-teacher interaction and enable cooperative learning, increasing student motivation. With the increase in mobile device usage, the potential to use augmented reality applications on these devices has increased.

In some studies, Augmented Reality applications have been used with mobile devices by being integrated with QR codes. According to Wang et al. [22], the utilization of AR applications in different fields of computer science has supported the increase in student motivation to learn the course content and also in the increase in their pedagogical strategies. Furthermore, researchers claim that augmented reality environments supported by mobile devices, where learning occurs with students involving their emotions and prior knowledge, can create more effective learning environments.

Sahrim (2023). [23] Argued that AR encourages student-centered exploration and enables data collection and observation when fieldwork is impossible. AR allows the visualisation and manipulation of abstract phenomena and hazardous or far places to be visited. It also permits contact with students or instructors and instantly enables online access to research material.

According to Alzahran (2020)[24], augmented reality (AR) is a powerful pedagogical tool that is gaining more and more attention to supplement and enhance learning at all levels of education by superimposing three-dimensional images over real environments. Although AR has been known to improve academic understanding, to our knowledge, there has been no methodical review of the usefulness and challenges of AR used in the e-learning context. AR is an auxiliary means to bring home the point regarding abstract topics. The author further explains that with better learning infrastructure, technology can increase pedagogical reach and allow for better and more effective teaching and understanding by students.

Yoon et al. (2012A)[25]. A project has conducted research examining the learning afforded by AR in an informal learning environment. Our previous study has shown that learning is primarily influenced by collaboration among peers while using the AR device, all the while preserving core aspects of informal participation, such as self-directed experimentation. In terms of the cognitive tools, results from experiments with our first two augmented devices demonstrate that AR can increase conceptual (content) understanding and cognitive (theorising) skills (Yoon et al., 2012B)[26].

To understand the affordances of the media, we have shown that learning is supported through the device's dynamic visualisation capabilities. Yoon et al. (2013)[27] reported that Different kinds and combinations of learning through digital platforms resulted in differentially beneficial learning outcomes. Based on the conceptual gains, the study concludes that nonsignificant learning gains and digital augmentations can provide pedagogically significant affordances for conceptual learning. It confirms that AR technologies visualised on museum devices are a valid and reliable method to promote conceptual gains, a substantial contribution to our understanding of informal learning. Even as AR technologies become more evident in museums, we must also understand their impact on visitors learning and cognisance. In contrast, it has been shown that they can encourage visitors to explore objects more (Szymanski et al., 2008) [28].

Aleksandra et al. (2019). [29] reported that AR combines real and virtual objects, which is what is the so-called continuum where AR is closer to the real world. There are various optical tracking systems, such as markerless technology, which allows objects in the real world to be used as markers. With different phases, marker-based technology allows a more rigid location for a virtual model and spatial technology, which is data-driven. GPS / GLONASS, gyroscope, and compass are built into mobile devices. AR, however, is closer to the real world.

Aleksandra et al. (2021). [30] emphasise that when freely available to most people, such as gadgets, laptops, and computers, it is difficult for a modern person to imagine the atmosphere in which the old masters worked and what type of materials and tools they used to create their masterpieces. Augmented reality will be able to show this process and recreate the authentic atmosphere of ancient times. In addition, the possibilities of this technology are so extensive that it becomes real to present the observer with virtual museum halls, supplying an opportunity to meet historical figures and examine artefacts in detail.

The Royal Ontario Museum has used augmented reality in the 'Ultimate Dinosaurs' application to add flesh to physical dinosaur bones in a virtual space. Visitors used the smartphone application to find markers around the exhibition [31]. The Atlas project [32&33], with the use of augmented and mixed reality, has real models of objects in a virtual interactive space.

Yoon et al.(2017). [34]& (Honey & Hilton, 2011) [35] reported that digital simulation and dynamic visualisation tools have helped ameliorate learning challenges by providing scaffolding to help students understand various aspects. In this study, the researchers hypothesise that students better understood Bernoulli's challenging science concept principle by interacting with augmented reality (AR) technology. They show that even given a short period for investigation in a science museum, students in the AR condition demonstrate significantly more significant gains in knowledge than students in the non-AR condition through interview responses.(Kim & Hannafin, 2011)[36].

Augmented reality (AR) technologies have been accentuated for their enormous potential to enable individuals to construct new understandings. By layering digital exhibitions (known as "digital augmentations") over real-world environments, the hybrid presentation of phenomena provides platforms for users to experience and perceive virtual elements as part of their current world (New Media Consortium, 2014)[37]. In so doing, the augmentations assist users to explore aspects of the world more substantially than possible.

The potential to augment users' interactions, attention, and experiences has demonstrated numerous affordances of AR for science education. These incorporate supporting students' scientific spatial ability by permitting them to manipulate and learn content in three-dimensional perspectives (Kerawalla et al., 2006)[38]; (Martín-Gutiérrez et al., 2010)[39].

Dunleavy et al. (2009). [40] reported that their study aimed to explore how teachers and students describe and understand the contributions of augmented reality (AR) simulations. The researchers conducted multiple qualitative case studies across two middle schools and one high school to capture AR simulations' advantages and limitations from student and teacher perspectives. Data were assembled through formal and informal interviews, direct observations, website postings, and site documents. Both teachers and students expressed that the technology-enhanced narratives and the AR simulations' interactive, situated, and collaborative problem-solving features were highly engaging, particularly for students who had previously faced behavioural and academic challenges. The AR simulation offered potentially transformative benefits while presenting unique technological, managerial, and cognitive challenges to the educational process (Rosenbaum, Klopfer, & Perry, (2007)[41]; Squire & Jan, (2007)[42]; Squire & Klopfer, (2007)[43].

Research instrument

The research used an instrument such as questionnaires to obtain the data
Containing five statements measuring the level of student reflective thinking in augmented reality. The questionnaires contained five statements redesigned from previous studies [45] [46][47]. These items were selected to align with the present study's objective of gathering students' perspectives on augmented reality technology.

Numeric Estimate

Five levels of the Likert scale indicate the perception level of using augmented reality as a learning method in the classroom. Among the answer choices are strongly disagree (SD =1), disagree (D =2), neutral (N =3), agree (A =4), and strongly agree (SA=5). Data were analysed using the statistical package for the social sciences (SPSS) software.

The researchers referred to the interpretation outlined in [48] to determine the levels of mean scores obtained, as shown below:

Statistical methods used:

The researchers employed the Statistical Package for Social Sciences (SPSS 25) to conduct statistical analyses and the methods used in the Pearson correlation coefficient.

1- Cronbach Alpha Coefficient.
2- Frequency and Percent.
3- Frequency and Percent. Mean and Standard Deviation.
4- Calculating the arithmetic mean for each statement to identify the degree of
5- agreement with each statement of the questionnaire as follows
6- Frequency and Percent. Mean and Standard Deviation.

Calculating the arithmetic mean for each statement to identify the degree of agreement with each statement of the questionnaire as follows:

The statements are arranged according to the arithmetic mean values (and if the means are equal, the smaller standard deviation is used)

Chi-square test for goodness of fit.

Range equation:

To describe the arithmetic mean of responses to each statement of the questionnaire on a five-point Likert scale, the response degree for each statement was determined and If the arithmetic mean value is :

- From (1) to less than (1.80), the degree of agreement is (Strongly disagree=SD).
- From (1.80) to less than (2.60), the degree of agreement is (Disagree=D).
- From (2.60) to (3.40), the degree of agreement is (Neutral= N).
- From (3.40) to (4.20), the degree of agreement is (Agree=A).
- From (4.20) to (5), the degree of agreement is (Strongly agree=SA).

1. **Mann–Whitney (U**) test for one-way comparison between high and low scorers.
2. **Paired samples (T-test)** for the significance of differences between the pre- and post-tests
3. **Validity and reliability** of the reflective thinking scale of the internal consistency validity results.

To verify the validity of the questionnaire's internal consistency, the researchers calculated the correlation coefficient between the scores and the total scores of each item. The results are shown in Table (1).

Table (1)

Dimensions	Item no.	Correlation coefficient	P-value
Normal activity	1	0.77	0.01
	2	0.71	0.01
	3	0.68	0.01
	4	0.67	0.01
	5	0.69	0.01
Perceptions	6	0.70	0.01

	7	0.78	0.01
	8	0.87	0.01
	9	0.80	0.01
	10	0.74	0.01
Reflection	11	0.76	0.01
	12	0.74	0.01
	13	0.69	0.01
	14	0.81	0.01
	15	0.74	0.01
Critical Reflection	16	0.65	0.01
	17	0.67	0.01
	18	0.72	0.01
	19	0.66	0.01
	20	0.61	0.01

Table (1) shows the correlation coefficients between each item of the questionnaire and the total scores, which ranged between (0.61 - 0.87) and are all statistically significant. Thus, the questionnaire items are considered valid for what they were designed to measure.

Structural validity results

The researchers verified the questionnaire's structural validity by calculating the correlation coefficient between each scale dimension and its total scores.

The results are shown in Table (2).

Table (2)

Dimensions	Correlation coefficient	P-value
Normal activity	0.85	0.01
Perceptions	0.93	0.01
Reflection	0.94	0.01
Critical Reflection	0.89	0.01

Table (2) shows a statistically significant correlation between the scores of each dimension and the total scores of the scale, which ranged between (0.85 - 0.94), indicating the validity and homogeneity of the scale dimensions.

Reliability results

The researchers verified the scale's stability using Cronbach's Alpha Coefficient method; the results are shown in Table (3).

Table (3)

Dimensions	Items	Cronbach's alpha coefficient
Normal activity	5	0.74
Perceptions	5	0.81
Reflection	5	0.79
Critical Reflection	5	0.67
Reflective thinking	**20**	**0.92**

Table (3) shows the stability coefficients of the questionnaire and its dimensions, which ranged between (0.85 - 0.94) for the dimensions. The stability coefficient for the scale as a whole reached (0.92), an acceptable stability rate that reassures the researchers about the results of applying the scale.

Discrimination ability (Z).

The researchers used the Mann-Whitney test to indicate the differences between the average ranks of the scores of the high-and the low scoring group of students on the reflective thinking scale statements. The results is shown in Table (4).

Table (4) implies that there are statistically considerable differences at the level (≤ 0.05) between the intermediate ranks of the scores of the group of high and low-scoring students on the reflective thinking scale statements. The values of “Z” varied between (2.96 - 4.84) while all were statistically significant. The outcomes indicate that the discriminating capacity of the scale statements is appropriate.

Table (4)

Dimensions	Item no.	High score group (N1 = 15)		Low score group (N2 = 15)		Z	P-value
		Mean Rank	Sum of Ranks	Mean Rank	Sum of Ranks		
Normal activity	1	19.50	292.50	11.50	172.50	3.20	0.001
	2	21.00	315.00	10.00	150.00	3.98	0.001
	3	21.00	315.00	10.00	150.00	4.01	0.001
	4	22.50	337.50	8.50	127.50	4.80	0.001
	5	20.50	307.50	10.50	157.50	3.72	0.001
Perceptions	6	20.00	300.00	11.00	165.00	3.46	0.001
	7	22.70	340.50	8.30	124.50	4.84	0.001
	8	19.00	285.00	12.00	180.00	2.96	0.003
	9	20.50	307.50	10.50	157.50	3.76	0.001
	10	21.50	322.50	9.50	142.50	4.25	0.001
Reflection	11	19.50	292.50	11.50	172.50	3.21	0.001
	12	20.50	307.50	10.50	157.50	3.73	0.001
	13	20.00	300.00	11.00	165.00	3.47	0.001
	14	19.50	292.50	11.50	172.50	3.23	0.001

	15	22.00	330.00	9.00	135.00	4.61	0.000
Critical Reflection	16	19.50	292.50	11.50	172.50	3.20	0.001
	17	21.00	315.00	10.00	150.00	4.00	0.001
	18	22.00	330.00	9.00	135.00	4.52	0.001
	19	21.50	322.50	9.50	142.50	4.25	0.001
	20	21.50	322.50	9.50	142.50	4.23	0.001

Results of the Statistical Hypothesis
The First Hypothesis Test:

The first hypothesis indicates, "There are statistically significant differences at the level (≤ 0.05) between the average scores of the research sample in the pre-and post-applications of the reflective thinking scale (Normal activity) toward of the post-application."

To confirm the validity of this hypothesis, the researchers used the Paired samples T-test to demonstrate the differences between the pre-and post-applications of the reflective thinking scale (Normal activity), and the results are shown in Table (5).

Table (5)

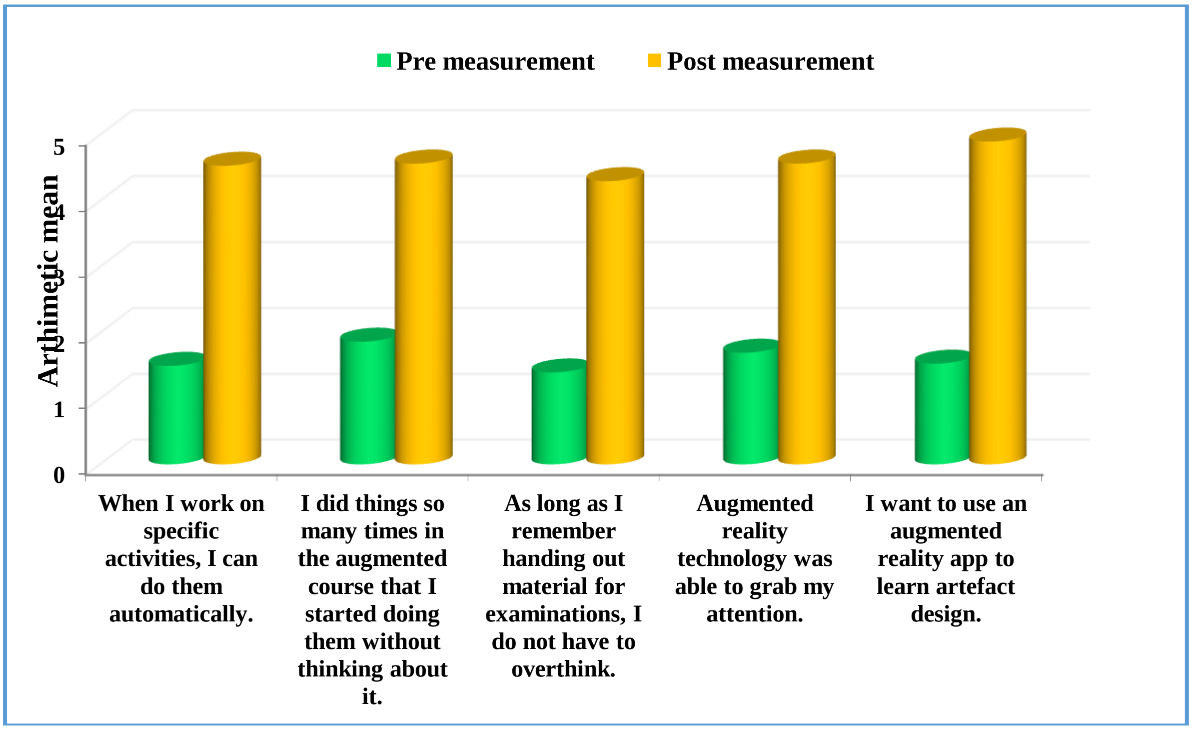
Items	Measurements	Mean	SD	Agreement	T-test		
					T	df	P-value
When I work on specific activities, I can do them automatically.	Pre measurement	1.50	1.01	SD	13.65	29	0.001
	Post measurement	4.53	0.57	SA			
I did things so many times in the augmented course that I started doing them without thinking about it.	Pre measurement	1.87	1.31	D	9.50	29	0.001
	Post measurement	4.57	1.07	SA			
As long as I remember handing out material for examinations, I do not have to overthink.	Pre measurement	1.40	0.62	SD	11.78	29	0.001
	Post measurement	4.30	1.24	SA			
Augmented reality technology was able to grab my attention.	Pre measurement	1.70	1.06	SD	12.27	29	0.001
	Post measurement	4.57	0.86	SA			
I want to use an	Pre	1.53	0.97	SD	17.84	29	0.001

augmented reality app to learn artefact design.	measurement						
	Post measurement	4.90	0.40	SA			
Normal activity	**Pre measurement**	**1.60**	**0.54**	**SD**	**23.59**	**29**	**0.001**
	Post measurement	**4.57**	**0.38**	**SA**			

Table (5) illustrates that there are statistically significant differences (≤ 0.05) between the average scores of the research specimen in the pre-and post-applications of the reflective thinking scale (Normal activity) in favour of the post-application.

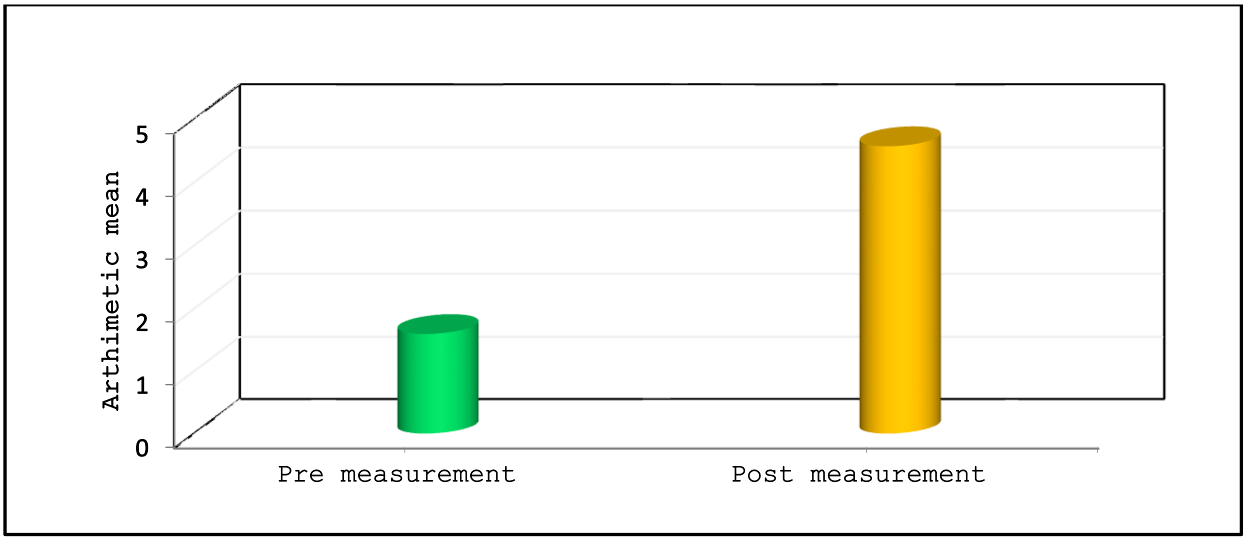
As the arithmetic mean values of the Normal activity dimension items at the pre-application ranged between (1.40 - 1.87) and came to a level between (Disagree, Strongly disagree), and the arithmetic mean values in the post-application ranged between (4.30 - 4.90) and came at a level of (Strongly agree), but the "t" values ranged between (9.50 - 17.84). All of them are significant at a level of (0.001).

The arithmetic mean of the Normal activity dimension in the pre-application was (1.60) at (Strongly disagree), while in the post-application, it was (4.57) at the same level; the "t" value was (23.59), and the significance level was (0.001) as shown in graph (1&2).



Graph (1)

Shows the average scores of the research sample in the pre-and post-applications of the items of .the (Normal activity) dimension



Graph (2)

Shows the average scores of the research sample in the pre- and post-applications of the dimension (Normal activity).

From Table (5) and the two graphs (1 & 2), It is clear that the first hypothesis of the research has been achieved.

Results of the second hypothesis test:

Perceptions scale

The test stated, "There are statistically significant differences at the level (≤ 0.05) between the average scores of the research sample in the pre-and post-applications of the reflective thinking scale in favour of the post-application."

To verify the validity of this hypothesis, the researchers used the paired samples T-test to indicate the differences between the pre-and post-applications of the reflective thinking scale, and the results as shown in table(6):

Table (6)

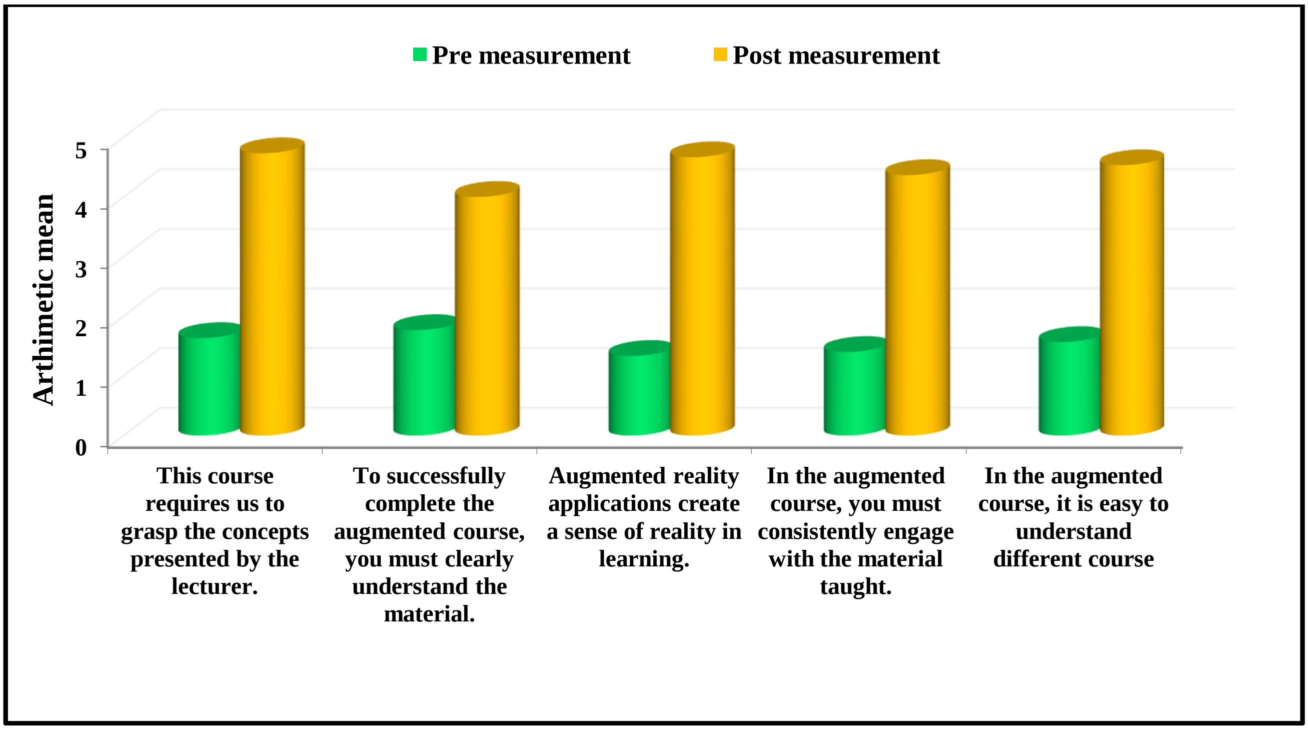
Items	Measurements	Mean	SD	Agreement	T-test		
					T	df	P-value
This course requires us to grasp the concepts presented by the lecturer.	Pre measurement	1.63	1.16	SD	13.68	29	0.001
	Post measurement	4.73	0.52	SA			
To successfully complete the augmented course, you must clearly understand the material.	Pre measurement	1.77	0.77	D	8.28	29	0.001
	Post measurement	4.00	0.95	SA			
Augmented reality	Pre measurement	1.33	0.80	SD	19.80	29	0.001

applications create a sense of reality in learning.	Post measurement	4.67	0.55	SA			
In the augmented course, you must consistently engage with the material taught.	Pre measurement	1.40	0.62	SD	15.24	29	0.001
	Post measurement	4.37	0.72	SA			
In the augmented course, it is easy to understand different course	Pre measurement	1.57	0.90	SD	14.39	29	0.001
	Post measurement	4.53	0.78	SA			
Perceptions	**Pre measurement**	**1.54**	**0.46**	**SD**	**23.11**	**29**	**0.001**
	Post measurement	**4.46**	**0.42**	**SA**			

Significance of the differences between the average scores of
The research sample is in the pre-and post-applications of the Perceptions scale**.**

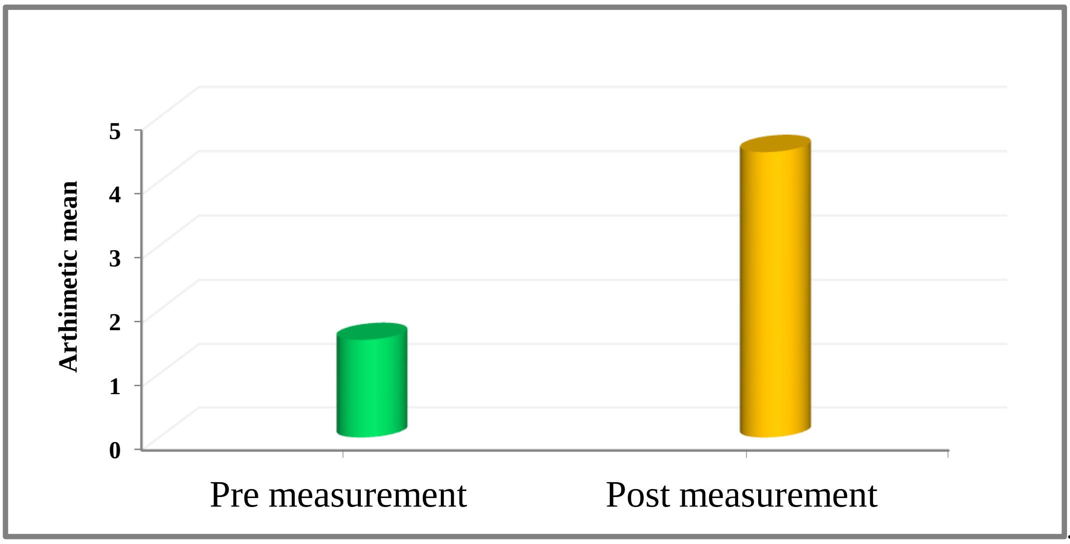
Table (6) shows that there are statistically significant differences (≤ 0.05) between the average scores of the research sample in the pre and post-applications of the reflective thinking scale (Perceptions) in favour of the post-application.

The arithmetic mean values of the Perceptions dimension items in the pre-application ranged between (1.33 and 1.77) and at the level of (Strongly disagree). The values in the post-application ranged between (4.0 - 4.73) and at the level between (Agree and Strongly Agree). The "t" values ranged between (8.28 and 19.80), and all of them were significant at the level of (0.001). The arithmetic mean of the Perceptions dimension in the pre-application was (1.54) and at the level of (Strongly disagree), and in the post-application (4.46) and at the level of (Strongly agree). The "t" value was (23.11) and the significance level (0.001). Figures (3 &4) illustrate this:



Graph (3)

Graph (3: Shows the average scores of the research sample in the pre- and post-applications of the items of the (Perceptions) dimension



Graph (4):

Shows the average scores of the research sample in the pre-and post-applications of the dimension (Perceptions).

Table (6) and graphs (3 &4) clearly show that the second hypothesis of the research has been achieved.

Results of the third hypothesis test:

The Reflective Thinking Scale

The third hypothesis states, "There are statistically significant differences at the level (≤ 0.05) between the average scores of the research sample in the pre-and post-applications in favour of the post-application."

To verify the validity of this hypothesis, the researchers used the Paired samples **T**-test to indicate the differences between the pre-and post-applications, and the results are in Table (7):

Table (7) shows that there are statistically significant differences (≤ 0.05) between the average scores of the research sample in the pre- and post-applications in favour of the post-application. The arithmetic mean values items in the pre-application ranged between (1.30 - 1.60) and at the (Strongly disagree) level. The arithmetic mean values in the post-application ranged between (4.43 - 4.83) and (Strongly agree) level. The "T" values ranged between (10.43 and 19.77). All of them are significant at the (0.001) level and the arithmetic mean value in the pre-application was (1.46). At the (Strongly disagree) level and in the post-application, it was (4.61), and at the (Strongly agree) level, the "T" value was (28.68). The significance level was. (0.001)

Table (7)

Items	Measurements	Mean	SD	Agreement	T-test		
					T	df	P-value
I occasionally question how others do things and consider better methods.	Pre measurement	1.40	0.93	SD	17.68	29	0.001
	Post measurement	4.70	0.65	SA			
I like to reflect on my activities and explore alternatives.	Pre measurement	1.53	0.97	D	14.72	29	0.001
	Post measurement	4.57	0.73	SA			
I often reflect on my actions to see whether I could have improved on what I did.	Pre measurement	1.47	0.94	SD	17.30	29	0.001
	Post measurement	4.83	0.38	SA			
I frequently reassess my experiences to learn and improve my next performance	Pre measurement	1.30	0.47	SD	19.77	29	0.001
	Post measurement	4.50	0.78	SA			
I believe augmented reality technology can improve my learning motivation	Pre measurement	1.60	0.93	SD	10.43	29	0.001
	Post measurement	4.43	1.01	SA			
Reflection	**Pre measurement**	**1.46**	**0.42**	**SD**	**28.68**	**29**	**0.001**
	Post measurement	**4.61**	**0.40**	**SA**			

Significant differences exist between the research sample's average scores in the pre-and post-applications of the Reflection scale**.**

From Table (7), its results, and the two graphs (5 & 6), it is clear that the third hypothesis of the research has been achieved. Graphs (5 &6) illustrate the results:

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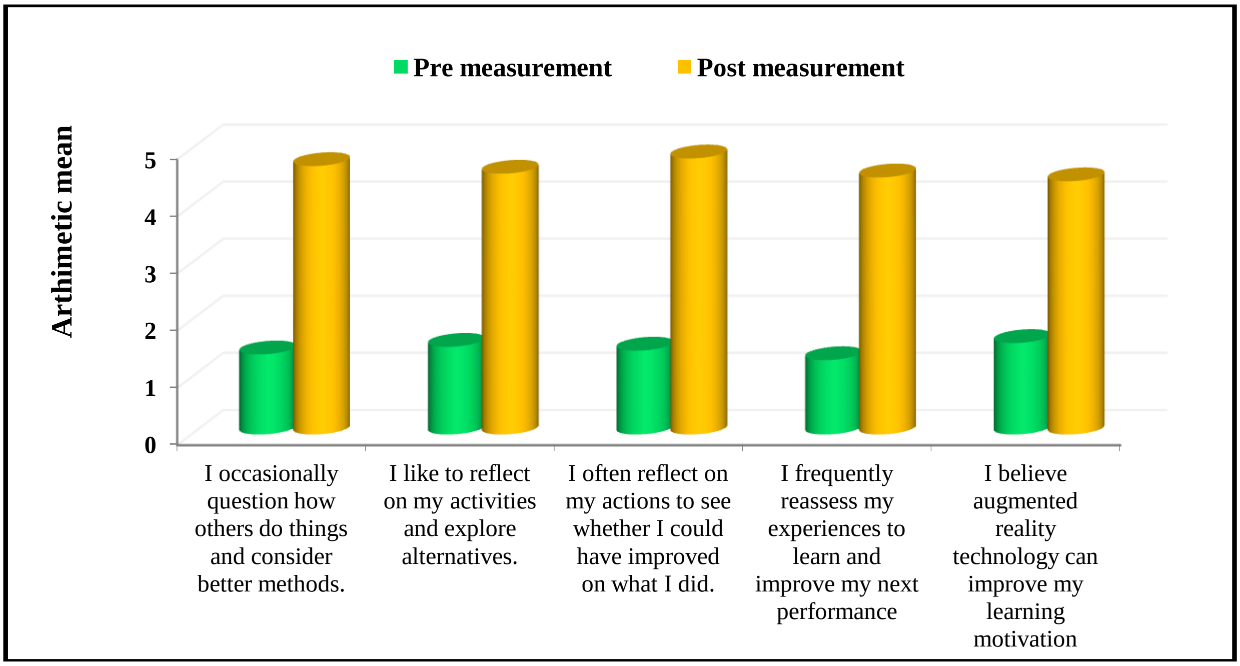
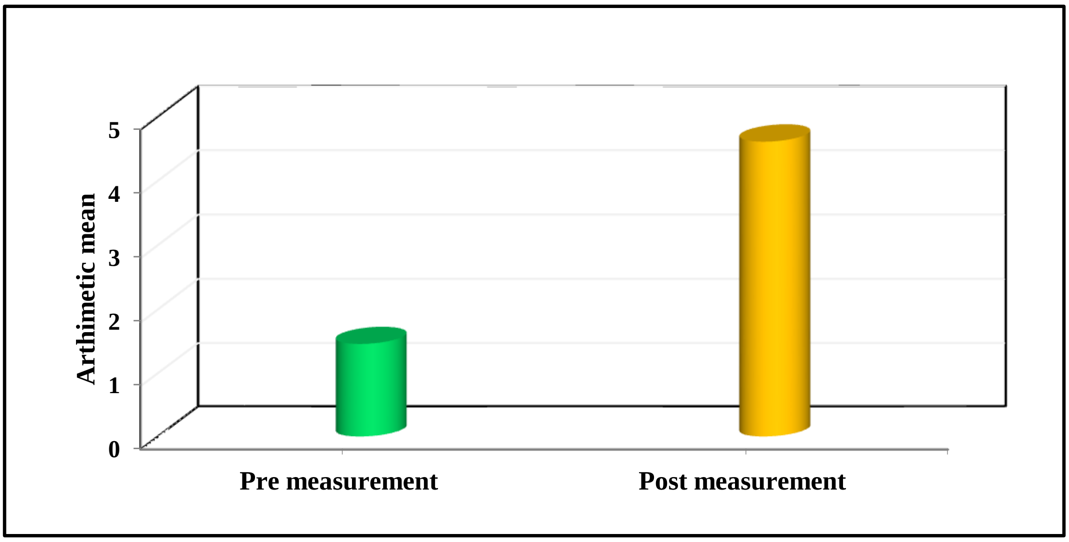


Graph (5)

Shows the average scores of the research sample in the pre- and post-applications of the items of .the (Reflection) dimension



Graph (6)

Results of the fourth hypothesis test:

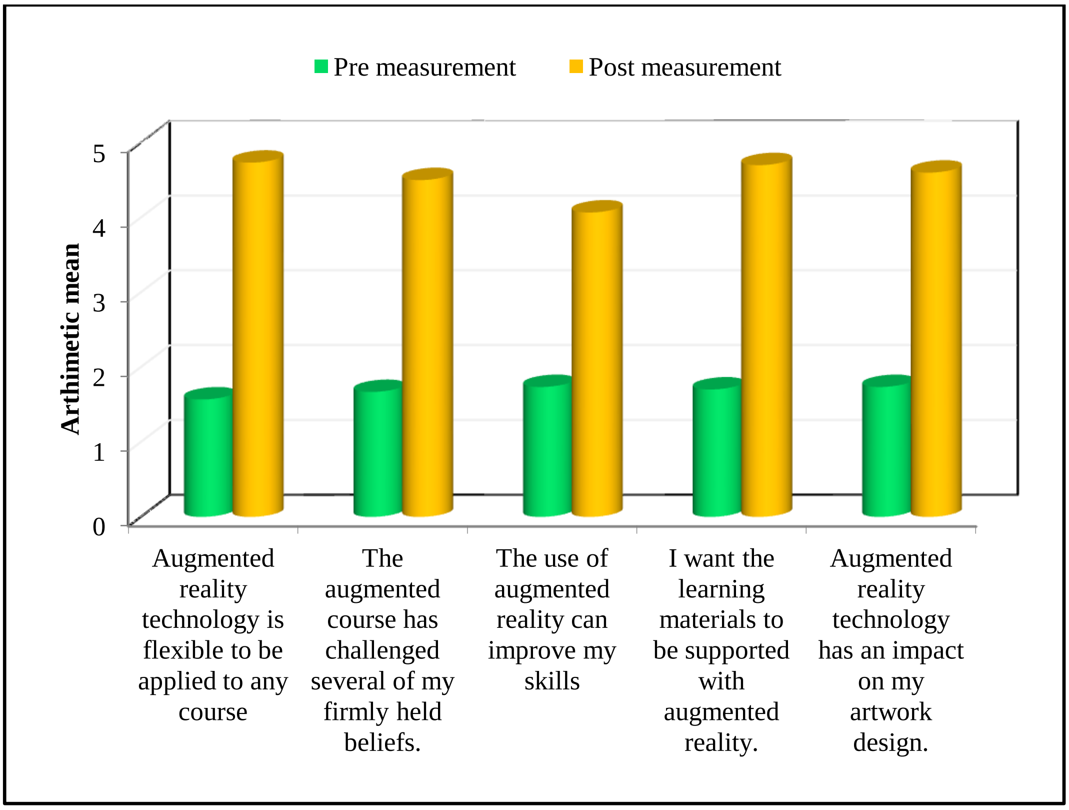
Critical Reflection scale

The fourth hypothesis states, "There are statistically significant differences at the level (≤ 0.05) between the average scores of the research sample in the pre-and post-applications in favour of the post-application."
To verify the validity of this hypothesis, the researchers used the Paired samples **T**-test to indicate the differences between the pre-and post-applications and the results as in Table (8).

Table (8)
Significance differences between the average scores of the research sample in the pre- and post-applications of the Critical Reflection scale

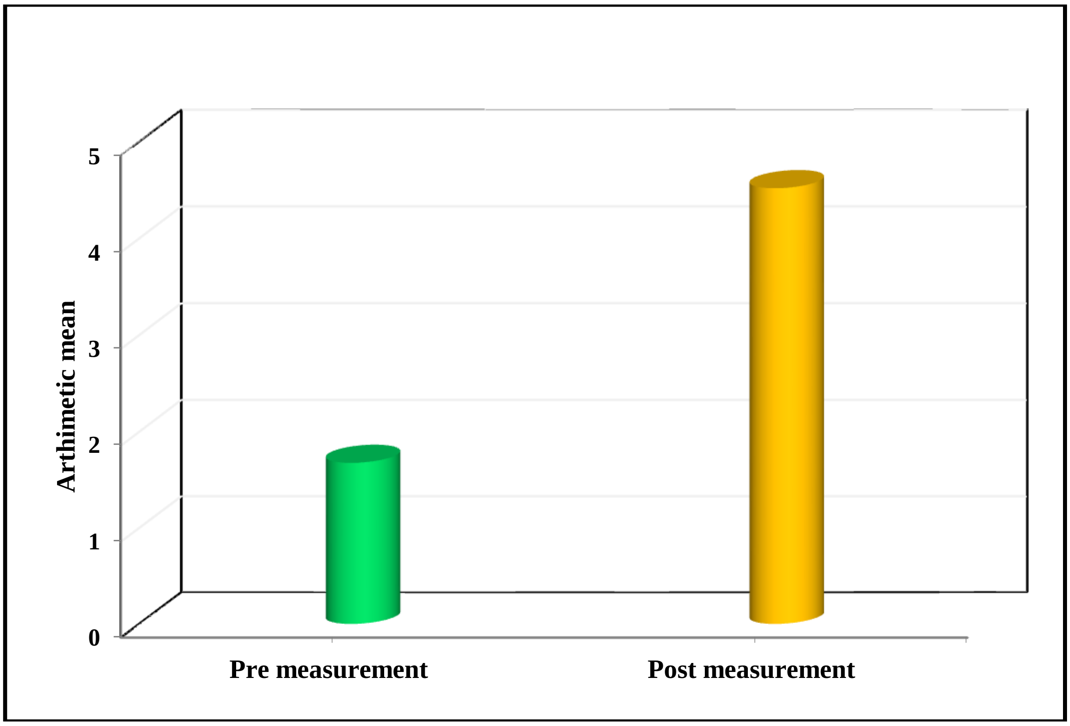
Items	**Measurements**	**Mean**	**SD**	**Agreement**	**T-test**		
					T	**df**	**P-value**
Augmented reality technology is flexible to be applied to any course	Pre measurement	1.57	1.04	SD	14.05	29	0.001
	Post measurement	4.73	0.52	SA			
The augmented course has challenged several of my firmly held beliefs.	Pre measurement	1.67	1.12	D	12.30	29	0.001
	Post measurement	4.50	0.78	SA			
The use of augmented reality can improve my skills	Pre measurement	1.73	1.11	SD	9.48	29	0.001
	Post measurement	4.07	0.87	SA			
I want the learning materials to be supported with augmented reality.	Pre measurement	1.70	1.12	SD	14.75	29	0.001
	Post measurement	4.70	0.53	SA			
Augmented reality technology has an impact on my artwork design.	Pre measurement	1.73	1.17	SD	12.02	29	0.001
	Post measurement	4.60	0.56	SA			
Critical Reflection	**Pre measurement**	**1.68**	**0.47**	**SD**	**24.23**	**29**	**0.001**
	Post measurement	**4.52**	**0.46**	**SA**			

Table (8) shows that there are statistically significant differences (≤ 0.05) between the average scores of the research sample in the pre-and post-applications of the Critical Reflection scale in favour of the post-application. The arithmetic mean values of the Critical Reflection dimension items in the pre-application ranged between (1.57 - 1.73) and the level of (Strongly disagree), and the arithmetic mean values in the post-application ranged between (4.07 - 4.73) and at the level of (Agree, Strongly agree). The "T" values ranged between (9.48 and 14.75). All of them are significant at the level of (0.001). The arithmetic mean of the Critical Reflection dimension in the pre-application was (1.68) and the level of (Strongly disagree), and in the post-application (4.52), the level of (Strongly agree), and the "**T**" value was (24.23) and the level of Significance in (0.001).as illustrated at Graphs (7 & 8).



Graph (7)

Shows the average scores of the research sample in the pre-and post-applications of the items of the (Critical Reflection) dimension.



Graph (8)
Shows the average scores of the research sample in the pre-and post-applications of the dimension (Critical Reflection).

Table (8) and the two graphs (7 &8) clearly show that the fourth hypothesis of the research has been achieved.

Verifying the Effectiveness of Augmented Reality Application in Reflective Thinking in Art Education

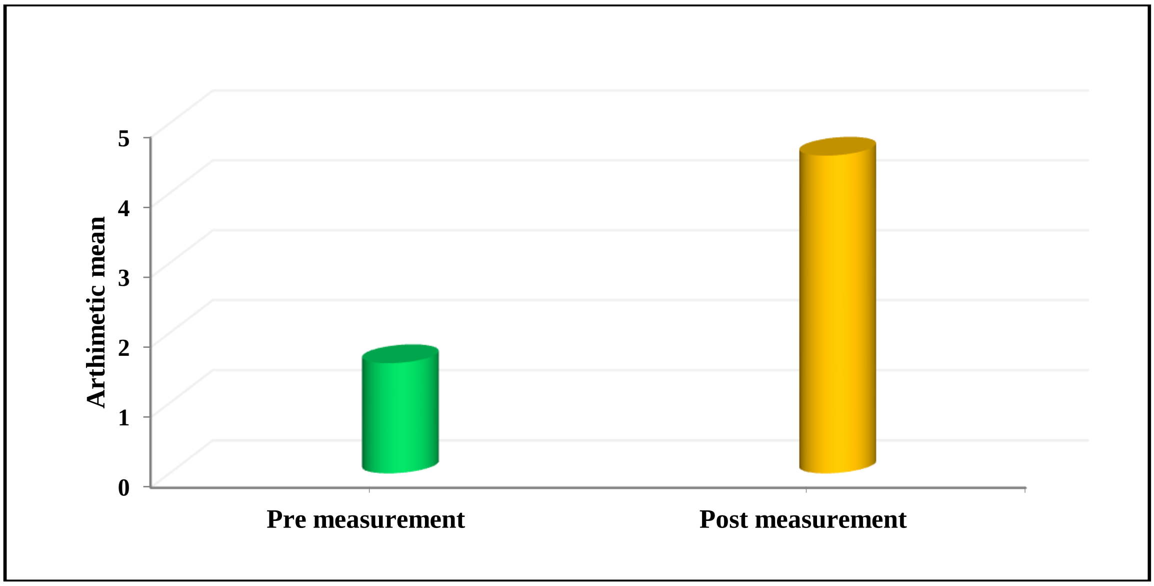
"There are statistically significant differences at the level (≤ 0.05) between the average scores of the research sample in the pre-and post-applications in favour of the post-application."

To verify the validity of this hypothesis, the researchers used the Paired samples T-test to indicate the differences between the pre-and post-applications, and the results are indicated in Table (9).

Table (9)

Scale	Measurements	Mean	SD	Agreement	T-test		
					T	df	P-value
Reflective Thinking	Pre measurement	1.57	0.35	SD	33.90	29	0.001
	Post measurement	4.54	0.28	SA			

Table (9) shows that there are statistically significant differences (≤ 0.05) between the average scores of the research sample in the pre-and post-applications in favour of the post-application. The arithmetic mean for the pre-application was (1.57), and the level of (Strongly disagree), and in the post-application (4.54) and (Strongly agree), the value of "T" reached (33.90). The significance level was.(0.001) . As indicated in graph (9).



.Graph (9)
Shows the average scores of the research sample in the pre- and post-applications of the Reflective Thinking Scale.

Critical Reflection
The sixth hypothesis states, "Integrating augmented reality into art education achieves appropriate effectiveness in applying reflective thinking among university students."
To verify the validity of this hypothesis, the researcher used the Mac Gogian equation to calculate the effectiveness ratio for integrating augmented reality into art education. Mac Gogian set the ratio (0.6) to judge the effectiveness, and the results were as follows:

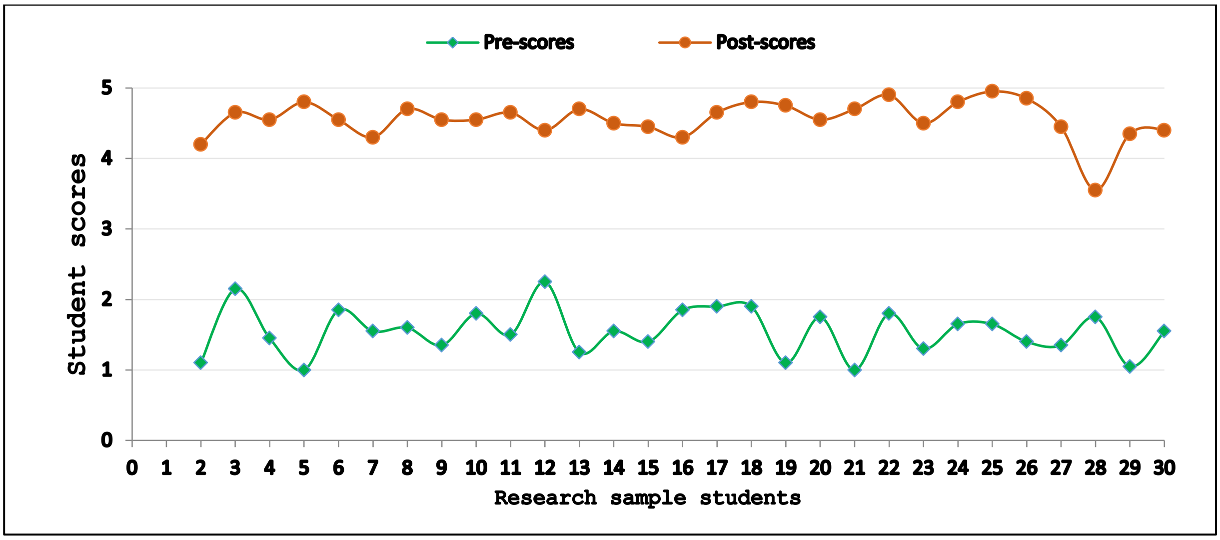
Table (10)

Dimensions	Measurements	Mean	SD	highest score	Effectiveness ratio
Normal activity	Pre measurement	1.60	0.54	5	0.875
	Post measurement	4.57	0.38		
Perceptions	Pre measurement	1.54	0.46	5	0.844
	Post measurement	4.46	0.42		
Reflection	Pre measurement	1.46	0.42	5	0.889
	Post measurement	4.61	0.40		
Critical Reflection	Pre measurement	1.68	0.47	5	0.855
	Post measurement	4.52	0.46		
Critical Reflection	**Pre measurement**	**1.57**	**0.35**	**5**	**0.866**
	Post	**4.54**	**0.28**		

	measurement				

The effectiveness of integrating augmented reality into art education is the appropriate effectiveness in applying reflective thinking among university students**.**

Table (10) shows the effectiveness ratios of integrating augmented reality into art education as appropriate effectiveness in applying reflective thinking among university students, as the scale dimensions ranged between (8.44 and 889). The total effectiveness ratio reached (0.866), which indicates that the use of augmented reality was effective and led to the application of reflective thinking among university students. As illustrated in Graph (10).



Graph (10)
The effectiveness of integrating augmented reality into art education is appropriate effectiveness in applying reflective thinking among university students.

As indicated by Table (10) and graph (10), the sixth hypothesis of the research has been achieved.

Discussion and Conclusion

1. The research analysis found that all four statements, each divided into five categories of 20, recorded mean value readings at a high level. As observed in the tables above, learning artwork using augmented reality is the most recent learning method that students are interested in. This data demonstrates that augmented reality technology can capture students' interest.
2. The current research identifies the efficacy of AR-based learning in promoting reflective thinking among a sample of students enrolled in AR-based classes in higher education.
3. Results indicated a positive response to using AR technology to learn all dimensions of reflective thinking. In addition, the qualitative analysis and the thematic coding yield four main themes: regular activity, Perceptions, Reflection, and Critical Reflection.
4. Our findings in this study, which investigated the use of AR devices, convince us that AR can support learning in informal environments through specific scaffolds. We have shown in this study that AR not only supports the education of artwork content but can also support the teaching of very challenging aspect content during brief periods of

exploration. Nevertheless, in the context of this study, there are no surveys on the use of augmented reality technology, particularly among students at the public university level.

Recommendation

1. The researcher recommends that the Applied Education and Training Art Department at Kuwait University's education system benefit from integrating AR into learning and providing training programs for students and instructors.
2. It emphasises that using AR in education is essential in preparing professional students.
3. University instructors should develop digital competencies, especially in integrating AR into teaching and course delivery.
4. Networking with peer institutions and developing educational policies and strategies to merge AR into education are recommended.
5. The research has some limitations; the novelty of AR technology requires instructors and students to be familiar with this emerging AR in learning, and training programs should be provided for students and instructors.
6. Researchers believe using AR to enhance students' reflective thinking and artwork improves course material visualisation for better understanding.
7. AR technology applications in pedagogy can change conventional learning methodologies by making them more immersive, interactive, and prosperous at engaging learners and facilitating knowledge acquisition.
8. According to Schrier [49], students can gain many skills using augmented reality applications, such as interpretation, critical thinking, problem-solving, information management, group work, and flexibility.
9. Students should use Augmented Reality applications at home and during lessons and give feedback to stimulate future studies.
10. 14. Finally, further research is needed to identify students' confidence levels using AR.
11. Students should use Augmented Reality applications both at home and during lessons and give feedback to stimulate future studies. QR codes enable Scavenger hunts to be used on smartphones, for example, learn mathematics or library categorisation. Students can help AR technology developers by sharing their experiences with them.

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