Shaping Future Educators: Attitudes toward Augmented Reality Adoption in Teaching

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***Abstract*—The study aims to explore the attitudes of pre-service teachers towards applying augmented reality in education. The sample in this mixed-method study includes 30 teachers in pre-service education who participated in a workshop explaining the topic of augmented reality and its use in teaching. Following the workshop, participants answered a questionnaire consisting of 27 questions divided into eight determinants, namely: performance expectancy, effort expectancy, social influence, facilitation conditions, hedonic motivation, price value, habit, and behavioral intention. Four of the participants also took part in an in-depth interview. The results show that participants' inclination towards using augmented reality in education was positive, regardless of their specialization or training received. Specifically, several determinants scored high, such as performance and effort expectancy, hedonic motivation, habit and behavioral intention, that positively affected participants' attitude. These results are also consistent with the cognitive load theory, which states that the educational environment enhanced with augmented reality helps learners in retrieving and remembering information, consequently resulting in reducing the cognitive burden on them. The study, however, also uncovered obstacles that may hinder the process of implementing augmented reality in teaching, such as the lack of facilities and high cost. Furthermore, the study recommends providing training courses to help teachers with the initial efforts in understanding how to implement augmented reality technology in the classroom.**

***Keywords*—augmented reality, cognitive load theory, pre-service teachers**

I. Introduction

It is the primary role and responsibility of the teacher to integrate technology in the educational process, and this is what modern educational policies have required from teachers to do. It requires teachers to facilitate the integration of technology during education by transforming the material from being imaginary and intangible to a lived reality. This will enable students to interact with the education material using the physical, emotional and intellectual capabilities [1].

Teachers' education programs help pre-service teachers overcome obstacles that they face while teaching, reflect on their practices, and solve problems to better prepare them in transitioning from pre-service teachers to in-service teachers [2]. Pre-service teachers are practical education students who are being trained to become qualified teachers. Teachers, the common element in every educational system, play an important role in integrating and accepting technology into education. They are typically equipped with and familiar with modern classroom technology, making them more inclined to utilize these new educational tools in their future careers [3].

The importance of preparing pre-service and in-service teachers is to take advantage of the many educational benefits that the Augmented Reality (AR) technology can provide while reducing the perceived risks associated with its use [4]. Consequently, the extent to which teachers will benefit from the capabilities of virtual reality and AR in the future, depends on their perceptions, attitudes, and behavioral inclinations towards such technologies [5].

AR technology has proven its effectiveness when teaching different age education levels, by increasing their motivation to learn, encouraging the development of children's imagination and creativity, and helping in developing their scientific skills. AR also offers teachers the ability to control the educational process to suit their students, their level of understanding, their preferred method of teaching, and ability to present study materials that cannot be easily understood or assimilated, by using real, direct, and easy to understand experiences [6]. The awareness of current technological developments is also essential for creating a high-quality educational system [7].

The idea of integrating AR in the educational process has been researched for several years, and a study by Abualrob [8] concluded that there is a positive relationship between students' school performance and the use of AR in education. The study further recommends the teachers to think about how to stimulate their students in being active and enthusiastic about learning, by for example transforming school books into an interactive modality through the use of mobile phones and display screens [8]. Yet, there is evident that there is a need to ensure trainings for teachers and future teachers on AR technology, as well as ensure access, and integrate AR applications in schools' curricula [9].

Many studies have recommended increasing the amount of research on the use of AR in education. They have also recommended providing additional training and lectures on AR and its applications to pre-service teachers to improve their proficiency in using this technology in their teaching. It is also mandatory to work on providing them with the necessary skills to prepare study plans that include using AR to enrich the educational process [10]. Another study has recognized that considering the current advancement in technology, pre-service teachers must keep up with this pace, and be equipped with modern, powerful and exciting teaching tools [11]. They also must have the opportunity to learn and be trained on these tools to gain the necessary knowledge and skills to integrate AR in their teaching practice, so that it benefits the students, incite their interest in school materials, and generally contribute to their educational and scientific achievement [11].

While existing studies demonstrate that AR significantly

enhances student motivation, creativity, and scientific skills, and its integration into education necessitates teacher awareness and training, a gap remains in comprehending the attitudes of pre-service teachers toward adopting AR in their teaching practices. To this end, the study aims to answer the following research questions:

RQ1: To what extent do pre-service teachers intend to implement AR in their future lessons?

RQ2: Are there any differences in the inclination of pre-service teachers to apply AR in education depending on their specialization or level of training?

II. Literature Review and Theoretical Framework

In this section we describe the literature review in terms of benefits and challenges of using AR in education as identified in existing studies. Additionally, we describe Cognitive Load Theory (CLT) as a theoretical framework relevant to the research conducted within the field of AR.

A. Benefits and Challenges of Using AR in Education

Syawaludin and Rintayati [12] study showed that pre-service primary school teachers had a good perception towards the AR-based interactive multimedia to improve the quality of science learning, considering the interactivity the AR brings and the ability to display things as real and immersive. Along these lines, the study by Delello [11] showed the extent to which pre-service teachers accept the use of AR in education. Additionally, the study demonstrated that AR can positively impact learning experiences in the classroom, including increased motivation, participation, and teacher enthusiasm. Yet, the results of the study also showed that the process of integrating AR in the classroom is not without challenges, which includes: being time consuming for teachers to implement AR lectures; teachers lacking the necessary skills to use such technology; and the lack of the needed tools and materials. This is corroborated with the results of Castaño-Calle *et al* [13] study, which showed that participants have positive attitudes toward AR, but they possess little knowledge about it. Finally, the study by Atalay [11] states that pre-service teachers in their lessons should use AR as it increases student attention on the topic being lectured and it is often perceived as being a fun, interesting and meaningful way of learning.

B. Cognitive Load Theory

One of the theories suitable when studying educational media and its effectiveness in education is the Cognitive Load Theory (CLT). It is considered one of the theories that is a leading source in the field of educational technology [14]. The theory aims to improve educational materials and activities, which is done by developing design guidelines based on the knowledge of human cognitive structures [15]. The application of this theory is also recognized within the use of AR in education [16].

To reduce the cognitive load on students, it requires creating educational designs based on the individual's cognitive structure and tailored specifically to how information is stored in their memory, which is essential to achieve the highest level of learning. It is important to focus on the quantitative aspect of information, as it is one of the basic elements that characterize human thought, and this is reflected in the amount of information present in long-term memory [17]. If the learning process is implemented by using computers and instructional design, it reduces the cognitive load and mental effort spent on learning, as well as the knowledge of the learner's previous experience and analytical knowledge, which impacts the choice of teaching strategy in education [18].

The learning environment affects cognitive load through several factors, whether by distracting the learner's attention, or by enhancing the student's interaction with the educational material or task [19]. This study further proves that using AR can contribute to lowering the cognitive burden.

Cognitive load is divided into three types. The first type—*internal cognitive load*—occurs as a result of the complexity and difficulty of the academic content. The second type—*external cognitive load*—is generated as a result of using traditional teaching methods, that results in providing the learner with an extensive amount of important and unimportant information. Due to inability to cope with the information load, that leads to the distraction of the learner's concentration and attention. The third and final type—*effective cognitive load*—occurs as a result of the learner's active participation in learning, which results from their active interaction with new information, moving between the stimuli presented to them and the needed cognitive structure to process them [20].

The theory of cognitive load determines that what is responsible for the storage process is the limited capacity of working memory, and since any information that the learner wants to store must be processed in short-term memory, any excessive load on it leads to failure of learning. Thus, educational media must be designed in a way that takes into consideration these limitations [21]. The enhanced educational environment using AR, which is rich in virtual elements such as images and 3D shapes, makes it easier for the learner to retrieve and remember information, and this contributes to reducing the cognitive burden on the learner [22].

These studies highlight the importance of training, preparing and guiding pre-service teachers to use AR in the educational process. Additionally, these studies show the positive role and effects when using AR in the educational process, by also considering the obstacles that stand on the way to making AR more mainstream education method in teaching.

III. Methodology

The methodology of action research which combines between quantitative and qualitative approaches was used, as quantitative and qualitative methods were both utilized in the study [23].

A. Participants and Study Settings

Practical education pre-service teachers at a university were invited to attend a special workshop on the topic of AR and its use in teaching. These were students enrolled during the second semester of the academic year 2023–2024, in two departments: Basic Education and English Language Teaching. The workshop, which lasted for three hours. was attended by 30 participants who answered our call. Initially,

participants were introduced to AR and its use in the teaching process. Videos related to the topic were shown, and applications for AR that can be used in the teaching process were presented. Later, participants saw demonstrations of the use of wide range of AR applications in education. Additionally, it also involved preparing educational content utilizing AR. Fig. 1 shows some of the AR apps used during the workshop session.

Fig 1. Various AR apps used during the workshop: a) learning about the solar system in the subject of geography; b) learning about birds in the subject of biology; c) learning about the human organs in the subject of biology; d) learning letters in the subject of English language.

By the end of the workshop, participants answered a questionnaire, which also included a question whether they want to further participate in the research by conducting an in-depth interview. Using purposive sampling method, four participants were selected from among those who had the desire to continue with their participation. Two of them were studying in the Basic Education and two in English Language education. Informed consent was obtained from all participants in a written format. Fig. 2 depicts this process.

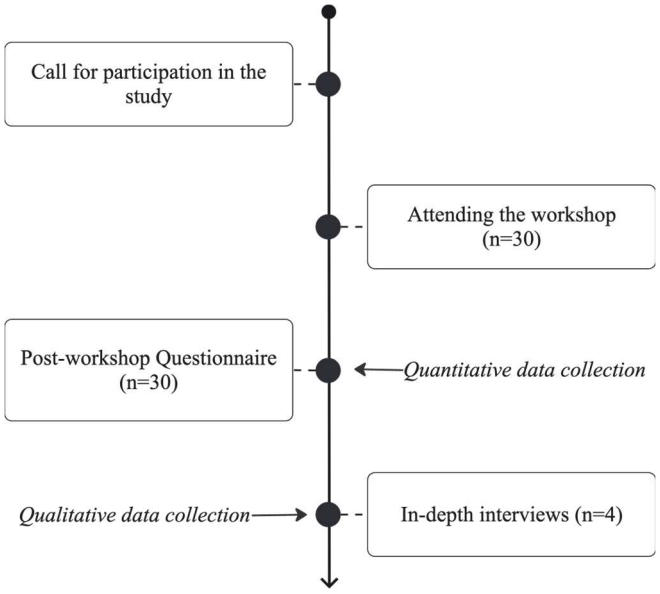

Fig. 2. Research procedure.

B. Data Collection

1) Questionnaire

A questionnaire, as a quantitative method, was used to measure the participant attitudes towards applying AR in education. The questionnaire is based on the study by Bower, DeWitt & Lai [24], which examined pre-service students' attitudes toward the application of virtual reality in education.

The questionnaire was translated from English to Arabic, with modifications made to suit the Arabic language context. To ensure the accuracy of the translation, the questionnaire was reviewed by a professor from the Department of English Language. Once the initial version was prepared, it was presented to experts for validation to ensure the questionnaire's appropriateness for the research objectives and its alignment with what it was intended to measure. After the experts provided their approval and suggested minor linguistic adjustments, the questionnaire was finalized for distribution.

The questionnaire in its final form consisted of two parts. The first part required the participants to offer demographic information about their specialization and level of training. In the second part, participants answered 27 questions distributed over eight determinants using five-point Likert scale. The questionnaire with the determinants, as listed in Table 1, was based on the extended Unified Theory of Acceptance and Use of Technology (UTAUT2) model in its construction, which is a model that provides a broad perception of the behavioral intention to use technology.

The strong theoretical and methodological foundations on which the model was built helped in disseminating this model and applying it in educational contexts [24]. The UTAUT2 model, which was adopted by Venkatesh *et al*. [25], was built on the UTAUT model. The first model included four determinants: *performance expectancy*, *effort expectancy*, *social influence*, and *facilitating conditions*. To this, there were added other four determinants: *hedonic motivation*, *value*, *habit*, and *behavioral intention*. This addition resulted in the presentation of a comprehensive model that integrates previous cognitive research, offering a holistic understanding of the factors influencing technology acceptance. Finally, the reliability of the questionnaire was confirmed by calculating Cronbach's alpha, which ranged between 0.831 and 0.976 across all eight areas.

Table 1. Survey questions and the respective determinants

Determinant	Question
Performance Expectancy	1. I believe that augmented reality is useful for teaching in schools.

	2. Using augmented reality increases my chances of achieving teaching goals.
	3. Using augmented reality is useful for quickly achieving more goals in teaching
	4. Using augmented reality helps increase my teaching productivity.
Effort Expectancy	5. I find that learning to use augmented reality is easy for me.
	6. I find augmented reality easy to use.
	7. My interaction with augmented reality technology is clear and understandable.
	8. It is easy for me to become skilled in using augmented reality.
Social influence	9. My professors at the university encourage me to use augmented reality in teaching.
	10.The university and university courses teach us and push us to use augmented reality in teaching.
	11.People whose opinions I value and who are good at using AR suggest that I should use AR in teaching.
Facilitation conditions	12.I have the resources necessary to use augmented reality.
	13.I have the necessary knowledge to use augmented reality.
	14.Augmented reality is compatible with other technologies I use.
	15.I can get help from others when I have difficulties using augmented reality.
Hedonic motivation	16.Using augmented reality is fun
	17.Using augmented reality is very entertaining.
Price value	18.Augmented reality is available at reasonable prices.
	19.Augmented reality is a good value for its prices.
	20.At the current price, augmented reality offers good resources.
Habit	21.Using augmented reality has become a habit for me.
	22.I frequently use augmented reality as part of my routine.
	23.I find it beneficial to use augmented reality in my teaching.
	24.Using augmented reality has become second nature to me.
Behavioral intention	25.I intend to continue using augmented reality in the future.
	26.I will always try to use augmented reality in my teaching.
	27.I plan to continue using augmented reality frequently.

2) Interviews

In-depth interviews were conducted with four participants using twelve questions (Table 2). After offering a brief presentation of the study and the purpose of the interview, permission was taken from participants to audio record the interview. The interview setup was developed with reference to previous similar studies [23, 26].

Table 2. Interview questions

	Interview Questions
1.	How would you describe yourself as an augmented reality user?
2.	Do you feel that your students are more interactive when using augmented reality? Please explain."
3.	How does using augmented reality help you in class?
4.	Can you describe how you make decisions about using augmented reality in your classroom?"
5.	Are you aware of how Indigenous teachers use AR with their students? Please explain
6.	What skills and knowledge do you find important to utilize in using augmented reality in your classroom?
7.	What types of professional development activities helped you learn to use augmented reality? How would you describe your training in using it?
8.	Do you feel that you are adequately prepared to teach complete educational content using augmented reality? Please explain.
9.	What additional training do you think will be necessary to prepare you to use augmented reality?
10.	How do you view the availability of augmented reality tools in relation to their prices?
11.	What is the role of the university and academic courses in pushing you towards learning to use augmented reality technology in education?
12.	What is your plan or strategy for using augmented reality technology in your future education practices

C. Data Analysis

1) Questionnaire analysis

To answer RQ1, which investigates participant intentions and future plans, the arithmetic mean and standard deviation were calculated for each of the eight determinants of the questionnaire, then those were also calculated for the entire questionnaire.

To answer RQ2, which investigates any differences between different specializations and levels of training, a t-test and Analysis of Variance (ANOVA) were conducted respectively. Two different specializations and five levels of training are provided on Table 3.

Table 3. Participant demographics

Demographics variable	Level	Number of Participants
Specialization/ Major	Basic Education	14
	English Language	16
Training Level	T1: Theoretical stage	0
	T2: Field experience of 60 hours in schools	2
	T3: Field experience of 90 hours in schools	12
	T4: Field experience of 90 hours in schools	10
	T5: Field experience of 120 hours in schools	6

2) Interview analysis

The analysis began by transcribing the interviews, which text was then read many times to get familiar with the content. The obtained answers were mapped to the eight determinants that were used in the questionnaire (see Table 1). The answers that belonged to one of these eight determinants were coded by highlighting sentences, phrases or paragraphs in the interviews text. These were then grouped and reorganized into meaningful themes depending on their cohesiveness.

This process is in line with Creswell's qualitative data analysis approach [26], which emphasizes the systematic nature of coding and organizing data into thematic units. It also follows the interactive model by Miles and Huberman [27], which entails three main components: data

reduction, data display, and drawing conclusions coupled with verification. Following these systematic processes allowed important patterns and relationships to come out of the data.

To ensure the validity of the analysis, the percentage of agreement was calculated by presenting a random sample of the interviews coding to a specialized analyst, and calculating the percentage of agreement between the researchers' coding and the specialized coding using the Cooper equation [28], where the percentage of agreement was 93%, which is an acceptable value.

IV. Results

This section presents the results that were obtained from the quantitative and qualitative approaches.

A. Quantitative Methods Results

Initially, we present in Table 4 the arithmetic mean and standard deviation for the eight determinants within the questionnaire. The results show that the arithmetic mean of the entire questionnaire was 3.4264 with a standard deviation of 0.37790, which is considered high. This is an indication that participants' inclination towards applying AR in education is high.

These results can be interpreted in the context of Cognitive Load Theory (CLT). High scores may suggest that AR technology reduces extraneous cognitive load by presenting information in a more intuitive and accessible manner, enabling learners to process complex tasks more effectively. Moreover, its engaging nature encourages learners to increase the cognitive load required for a deeper understanding and retention of educational content.

One of the aims of the study was to investigate any differences between the participants coming from two different majors. An independent samples t-test shows that the arithmetic mean and standard deviation for English Language participants is lower than for Basic Education participants. However, the t-test result, $t(28) = 0.122$, $p > 0.05$, indicates that there is no statistically significant difference between participants of these two majors with regards to their inclination towards applying AR in education. Further details are shown in Table 5.

Table 4. Arithmetic mean and standard deviation for the questionnaire

N	Axis	Arithmetic Mean	Standard Deviation	Degree
1	Performance expectancy	4.1250	0.47683	High
2	Effort expectancy	3.5500	0.59957	High
3	Social influence	2.8667	0.92060	Average
4	Facilitation conditions	3.0583	0.50294	Average
5	Hedonic motivation	4.3200	0.34575	Very high
6	Price value	2.5556	0.79430	Low
7	Habit	2.8750	0.59361	Average
8	Behavioral intention	3.9889	3.9889	High
	Total	3.4264	0.37790	High

This lack of significant difference is in line with the CLT, which suggests that AR technology universally reduces cognitive barriers, making learning more accessible to learners regardless of their backgrounds.

Table 5. The results of t-test to compare between the averages of the study's sample responses

Major	Participants	Mean	St. Deviation	T. Value	Probability	Significance
English Language	16	4.1992	0.33895	0.122	0.911	No sig.
Basic Education	14	4.2150	0.43113	0.122	0.911	No sig.

Another aim of this study was to investigate any variations in participants' attitudes and willingness to apply AR in education based on their varying levels of training. As detailed in Table 6, a one-way ANOVA results show no significant difference among different groups, namely, $F(3, 26) = 0.938$, $p > 0.05$.

Table 6. The results of the one-way ANOVA according to the training level variable

Source of Variance	Sum of Squares	Deg. of Freedom	Mean	F Value	Probability	Significance
Between Groups	0.405	3	0.135			
Inside the Groups	3.737	26	0.144	0.938	0.436	No sig.
Gross	4.142	29				

These quantitative results indicate that participants' willingness to implement and use AR technologies in their education process in the futures is high. Moreover, this attitude is the same in both education majors and does not depend on the training levels obtained.

The lack of significant differences across majors (Table 5) or training levels (Table 6) provides support for the universality of AR's impact, as per CLT's emphasis on universally accessible design. This consistency suggests that AR helps to reduce cognitive barriers for all learners, which aligns with the principles of the theory.

B. Qualitative Methods Results

As outlined in the interview analysis section, the interviews were analyzed using the eight key determinants to uncover additional insights for each determinant, which were represented as themes.

The in-depth analysis further revealed sub-themes for some of the primary themes, which strongly connect with quantitative data. An overview of all themes and sub-themes is provided on Fig. 3, whereas below we explain eacARh theme with the associated sub-themes along with participants comments.

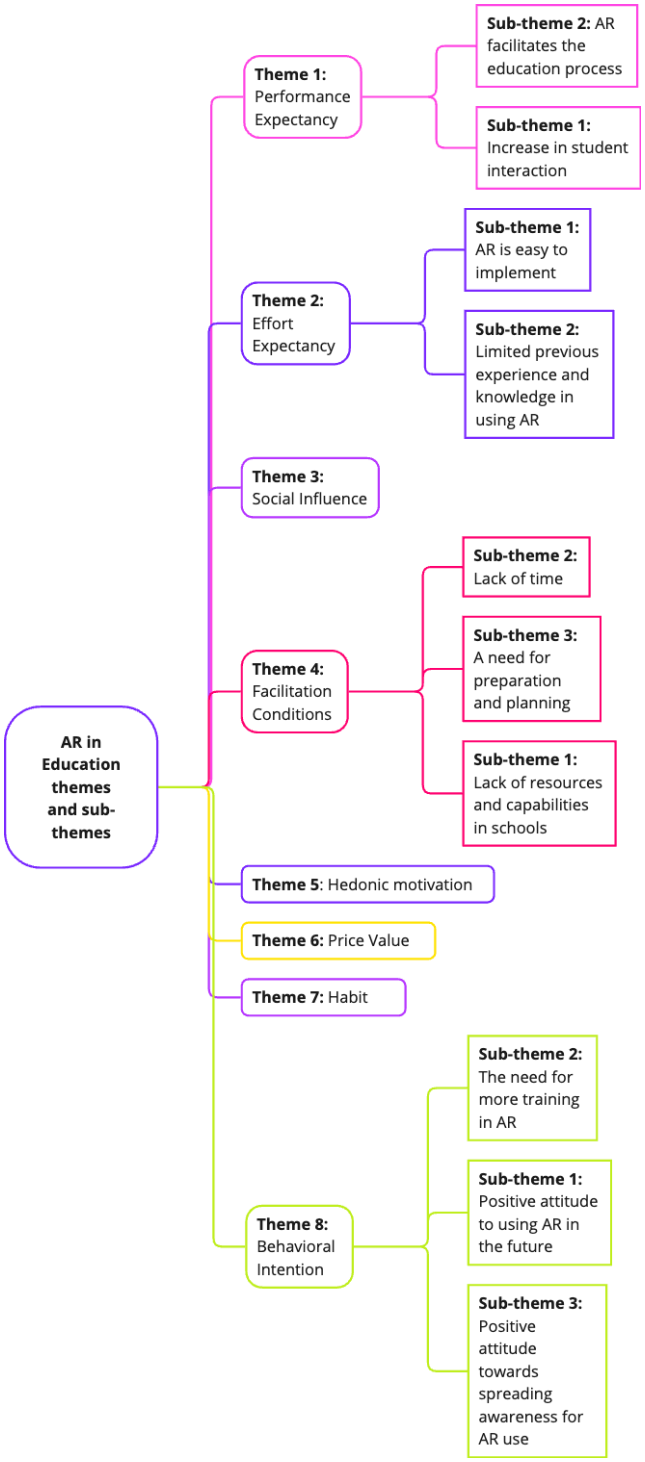

Fig. 3. Themes that were relied on in analyzing the interviews.

The identified themes and sub-themes align with CLT, as they reflect the participants' understanding of AR's role in reducing extraneous cognitive load by facilitating more effective and intuitive learning experiences. The findings also support the ability of AR to induce relevant cognitive load through engaging learners in meaningful and interactive activities that promote understanding and retention.

1) Theme 1: Performance expectancy

Participants claimed several reasons behind the ability of using AR in enhancing their performance, including the following:

a) Sub-theme 1: increase in students' interaction

Watching videos and pictures using AR technology and through the phone screen gives students a greater interaction with the content, as for instance some of the participants claimed:

"The students interacted with the class and their interaction was great and clear, especially since there was a use of a mobile phone. This is the reason why all the students focused and paid attention, because you know that we are in an era in our lives where mobile phones are the most important thing and we cannot live without them, neither we, nor the children." (P1)

"Another thing is that watching these lessons, practices, through a phone, I feel that it gives a more exciting and motivational character to the students." (P2)

"It is in children's nature to be excited about games, puzzles, pictures, and videos, in contrast to passively receiving knowledge." (P3)

These quotations confirm that the implementation of AR in education leads to an increase in students' interaction, which consequently contributes to better student involvement with teaching materials. Other benefits include enhanced focus and anticipation for the content presented on the phone screen, as the phone's potential to enhance student engagement in education is leveraged.

This aligns with CLT, as AR helps reduce unnecessary cognitive effort by delivering content in an engaging and intuitive format, which improves focus and enhances information retention.

b) Sub-theme 2: augmented reality facilitates the educational process

The participants indicated that using AR in the educational process facilitates the process of delivering information to students and helps them overcome reality, as they claimed:

"Augmented reality makes teaching and delivering the information to students easier." (P2)

"Through augmented reality applications, we are able to transfer experiments or difficult shapes into reality by bringing it in front of the students for them to see it right in front of their eyes. We are also able to make the shapes bigger, smaller, or even see the inside layers of the shapes. We are also able to use it to connect one content to another or use it as educational games." (P3)

"It provides plenty of help for teachers to achieve the most amount of learning goals." (P4)

These comments confirm that using AR in education helps in facilitating the educational process through the ability of explaining complex knowledge in an easier and understandable way by utilizing 3D technology and not just pictures in a schoolbook. Moreover, it helps in making the lessons easier to grasp through its transformation into an enjoyable educational game, and consequently helping teachers in achieving a greater number of goals in a short time.

2) Theme 2: Effort expectancy

This theme refers to the efforts that teachers may need to make in order to implement AR in education, and the simplicity and complexity of using it. Additionally, this theme includes few sub-themes.

a) Sub-theme 1: Augmented reality is easy to implement

Participants shared positive attitudes towards the easiness of implementing AR in education. Some of their comments include:

"It was my first time applying it in my lessons, but I saw that it is easy to use. I was not expecting it to be this way." (P1)

"It was kind of easy, especially that it was the first time we apply it to lessons and it was the first time for students to see it. I believe that the next time we use it, it will be better." (P2)

"The applications were very easy and fun to use. Any teacher has the ability to use it and it doesn't need a lot of effort and time, but its results are beautiful and motivational for teachers to use them again." (P4)

These comments confirm that using AR is easy and it could become even easier by repetitive use. It is also possible for teachers to face difficulties in applying AR in class for the first time, mainly due to preconceptions of its difficulty. However, it is easy to overcome these obstacles by encouraging teachers to try to actively use AR in their teaching process. Teachers should attempt to overcome the obstacles they may encounter when using this technology for the first time by trying to do it themselves.

This also aligns with CLT since the simplicity of AR reduces extraneous cognitive load for teachers, thus being easy to adopt and implement. Despite the challenges that come with initial unfamiliarity, repeated use will eventually give teachers an opportunity to build experience, streamline their efforts, and have more focus on effective teaching that enhances learning outcomes.

b) Sub-theme 2: Limited previous experience and knowledge in using AR

The participants indicated that they have no or limited experience in using AR, as they explained below:

"You are the first person to ever mention this topic to me." (P1)

"Frankly, I did not know anything at all about augmented reality before this workshop." (P2)

"After a person applies it in more than one lesson, they will know what the negatives of augmented reality are and what things they should avoid." (P3)

"I do not have enough experience, I mean, not 100%, but I have started to learn about it, and I can continue and continue until I have the required experience." (P4)

These participant comments confirm that they did not have previous knowledge of AR, and this could affect their teaching performance and increase the preparation load. Participants also indicated that workshops on the subject of AR are not sufficient, but one should try and use the technology to continuously improve their skills, and with that improve teaching performance.

3) Theme 3: Social influence

On the matter of social influence, participants indicated that they were not influenced by their surroundings to encourage them to implement AR. Some of their comments include:

"The teacher that trains me have not used augmented reality technology, because I think that she does not know about it. I mean, not that she does not want to use it, but she does not know anything about it." (P1)

"The teacher I was training with was surprised by the word augmented reality, and she told me that she did not know about it, and asked me to tell her more about it." (P2)

"I mean, teachers don't even try to get to know such new technologies like augmented reality." (P4)

These comments indicate that participants were not exposed to AR by their teachers during their education, and according to them it was because their teachers were not aware of the AR technology.

4) Theme 4: Facilitation conditions

The participants pointed out several issues that were an obstacle or may be an obstacle in the future towards using AR in education, which we present below into three sub-themes.

a) Sub-theme 1: Lack of resources and capabilities in schools

The participants indicated that the capabilities of the schools in which they trained were limited. Some of their comments include:

"Using augmented reality is easy, but I wish that there were more resources. It was nice and fun, but the problem was in the availability of resources." (P1)

"The first obstacle is the Internet because, for example, here in our school there is no internet access, and most of the augmented reality applications need Internet in order for us to be able to use them. Also, the problem of resources, meaning one mobile phone is not enough for the class because all the students are watching together. It is possible if every student has a mobile phone or if there are more than one cell phone in the school, that we can use, it will be better and it would save time." (P2)

These comments portray the reality of schools where participants teach, which suffer from a lack of basic resources and capabilities. Typically, the Internet is not available in their school, and if it is available, it is weak and cannot be relied on for using AR applications. Additionally, the lack of phones, hinders the use of AR in teaching activities, as it requires the teacher, through only one phone, to give students the opportunity to watch.

b) Sub-theme 2: Lack of time

Participants indicated that the class time may not be sufficient to use AR during lessons, as explained below:

"A large percentage of teachers during this period stopped caring about the diversity of teaching methods, and relied only on traditional teaching, because teachers have lots of material from the schoolbooks, whereas using different methods and activities may take time, although its benefits are greater and its results are better." (P3)

"Teachers' main concern is to finish the required material and to be able to present the greatest amount of information, which means there is no time for activities nor games, because you know that face-to-face education is still better than online classes given on (Microsoft) Teams." (P4)

These quotes suggest that the use of AR in education may require an additional class time in order for the teacher to be able to deliver the planned material.

c) Sub-theme 3: Preparation and planning

The need for preparation and planning is seen as essential by participants for the implementation of AR in class to be successful. Some of the participants stated the following:

"Giving a class using augmented reality requires planning and training beforehand." (P1)

"Because we were well prepared and everything was ready, it helped to make the class organized and coordinated and we accomplished a lot in it." (P3)

"When the teacher is well prepared and has planned the lesson well, and knows what she wants to do and which application she wants to use and at what time she wants to use it, and what procedures she must take in order to be able to use the application..." (P4)

These comments suggest that planning and preparing for the class beforehand is necessary to ensure that the class goes well and avoid any difficulties that may arise while using AR. Additionally, the interaction required while using this technology, may require additional efforts in maintaining the order in the classroom. Typically, depending on the lesson, a variety of AR applications might be applicable, thus this requires the teacher to research these apps and choose the best one for the planned class.

This addresses the CLT because the identified challenges, such as the lack of resources, time, and the need for preparation, highlight the importance of minimizing extraneous cognitive load. If these barriers are reduced through improved planning, increased resources, and structured facilitation, teachers would be better able to concentrate on delivering content effectively, thereby enabling AR to enhance the relevant cognitive load for deeper learning outcomes.

5) Theme 5: Hedonic motivation

Participants indicated that using AR in education was fun and entertaining, as stated below:

"I saw how the class was, and despite all the obstacles, it was very nice and enjoyable for the students, and it was something new for them." (P1)

"It is an amazing and enjoyable technology to use with students." (P4)

These comments suggest that using AR is enjoyable for students and it represents a new form of learning contributing to their increased interest in the material. This also indicates that students need such technology in a classroom in order to add an aspect of fun to school lessons. The student must be entertained while learning and not be forced to learn, in order to achieve better education.

6) Theme 6: Price value

Participants indicated that they had no previous knowledge of the prices of AR tools, and consider them to be high, as they commented:

"I saw that its price is relatively expensive." (P2)

"For our society and our reality, I see that the price of augmented reality tools is expensive and high." (P3)

"In my opinion, it is expensive, but I also don't know whether they are this expensive in all countries or because importing them for us is expensive, but in general the tools are expensive for us." (P4)

These comments indicate that AR tools are perceived as relatively expensive. These technologies are often considered too expensive for schools in developing countries, making it difficult for them to acquire such tools.

7) Theme 7: Habit

Getting into the habit of using AR would provide excellent results for education, as suggested by participants.

"I will use augmented reality, but not in every class, because it will become a routine and boring if we use it daily. I'd use it when there is a new idea in the lesson, if there is a difficult idea, if there is something they need to see with their own eyes, or for example, when I want to explain to them something tangible and difficult for me to provide. I can use augmented reality, so that they can see it as if it is in front of them." (P1)

"We can use augmented reality in more than one situation. We can use it with many materials or with all materials. I mean, I thought that I could use it in math, which I talked about before. It is an abstract subject. I mean, if I don't want to use it as a display of models, I can use it to create a fun educational game for students by using cards and one augmented reality app." (P3)

These comments suggest that the need for frequent use of AR applications in classroom is a positive aspect, however, it should not be part of every class, in order to avoid becoming a boring routine. Additionally, being selective when to use AR seems to contribute to students' serendipity levels and keeping the technology exciting.

8) Theme 8: Behavioral intention

Participants suggested ways in which AR technology use can expand, which we present in three separate sub-themes:

a) Sub-theme 1: Positive attitude to using AR in the future

Participants expressed their positive inclination to continue using AR during their training period, and also spend more time and improve their skills. Some of their comments were:

"I became curious, and I got very excited because I know more about it now, and the students will definitely get more and more excited. If we, the adults and teachers got excited about it, then they will definitely be more excited, and this is what we saw in today's class." (P1)

"After I learn it and apply it in school, I will not stop there. I will continue to learn more about its applications and watch more videos about it." (P2)

"I must keep on using it now while I am in the training period." (P4)

These comments suggest participants' commitment to continue using AR during their training and beyond. They also emphasize the desire to learn more about AR and the necessity and wish to acquire and improve the skills to integrate it in their lessons.

b) Sub-theme 2: The need for more training in AR

Participants expressed their opinion that they need more support from the University and the Ministry of Education, as their comments show below:

"I mean, if there are more workshops on augmented reality, I will definitely go, and I would also love after I graduate to take such courses because they will benefit me more and I will be more motivated." (P1)

"Responsibility is the first thing that falls on the university because we learn teaching methods from the university, and the second thing is that the responsibility also lies on the Ministry of Education and teachers we train with. I mean, if they don't know it and don't use it, how are we supposed to know about it?" (P3)

"Probably if there were more workshops or trainings on augmented reality, I would definitely participate in them." (P4)

These comments indicate participants' willingness to know more about AR, as they consider their knowledge to be limited. The university must provide special courses and

workshops on modern technologies, which should include the AR technology. The Ministry of Education must also support universities with facilities and resources.

c) Sub-theme 3: Positive attitude towards spreading awareness for AR use

Participants shared their desire to spread AR technology, and some of their comments below include ways in which they anticipate doing that:

"I see that the most important point for sharing any new topic is by using social media." (P1)

"It is possible that by preparing videos and sharing them on social media platforms, a large percentage of school and university students and even teachers will have knowledge about it. As soon as they see an advertisement like this, they will become curious to learn more about it. That will make them try it and use it if they know what its benefits are and how to use it in their classes." (P2)

"It is possible for us to spread augmented reality by having every teacher use it in a class. They can film it and upload it to YouTube." (P3)

"Every student in this workshop must tell other students about it, and he/she must also tell their teachers in the school where he/she is training in about augmented reality, and like this, everyone who knows will tell others which will make it spread quickly. It is also possible through the university, by making workshops and practical training on using augmented reality, even if its use is limited to the university, the important thing is that students apply it and learn how to use it." (P4)

These comments suggest that spreading awareness about AR technology is crucial to familiarize teachers with it. One effective way to achieve this is through social media platforms. Encouraging people to discuss and document their experiences with AR technology, such as filming videos and sharing them on YouTube, can further contribute to its widespread adoption.

This aligns with the CLT principle, as raising awareness and providing training reduces unnecessary cognitive load, making AR tools more user-friendly and enabling teachers to concentrate on achieving effective learning outcomes.

V. Discussion

A. Teachers' Positive Attitude to Implement AR in Education

The first question that guided this study was to investigate to what extent do pre-service teachers intend to implement AR in their future lessons. The results revealed their positive attitude towards applying AR in education by indicating their high level of inclination in several of the determinants within the questionnaire. For instance, determinants for *performance expectancy*, *effort expectancy*, *behavioral intention*, and *hedonic motivation* were high. Other determinants were on medium level aside from the *price value*, which was low.

The outcomes from this study align with other similar studies, especially in the determinants that scored high, which indicates that the AR is more likely to be embraced by teachers who recognize its potential benefits in improving student learning. Thus, teachers' positive attitude is supported by their stance that AR can increase content understanding in students, as well as improve interaction and class collaboration, enhance memorization, and increase student motivation [29]. Consequently, when teachers directly see and experience how AR can transform learning and in a way witness the positive student reactions, they are more likely to view this technology as a valuable tool [10].

Other aspects, such as institutional support and access to resources and infrastructure were highlighted as key elements encouraging teachers to spend time learning this technology, and consequently promoting positive attitude toward AR adoption, which align with the study by Delello [11]. Such support encourages teachers to make efforts to integrate this technology into a classroom, and they are more likely to experiment with it. Having access to the necessary equipment in terms of required hardware and software as well as technical support are seen as crucial elements to removing frustration associated with a novel technology, and as such could allow teachers to focus on the pedagogical aspects of AR integration [11].

Despite the positive attitude, teachers shared concerns about the initial difficulties they could face when using AR, which is addressed to the lack of experience that most teachers have. Thus, training opportunities and professional development with AR technology is essential to equip teachers with the necessary knowledge and skills. This would increase teachers' confidence and encourage more engagement with the AR technology. Similar results are also found in the study by Castaño-Calle *et al* [13], which states that teachers' proficiency with this technology directly contributes to them valuing it and using it in their teaching process.

B. Teachers' Positive Attitude Regardless of their Specialization or Training Level

The second question that guided this study explored the variations in attitudes toward applying AR in education based on the specialization track or level of training. The results show equally positive attitudes for teachers coming from Basic Education or English Language specialization track, as well as different levels of training, as listed in Table 3.

Similar results were found in the study by Delello [30] where participants from three different disciplines showed similar positive attitudes towards AR. Somewhat similar results were also shown in the study by Cabero-Almenara *et al*. [31], which reported a positive attitude towards accepting AR regardless of the courses participants were involved in. However, the study by Castaño-Calle *et al* [13], reported the differences regarding participant perception of the usefulness of AR between those in Preschool Education compared to those in Physical Activity Education. These differences suggest other confounding factors could be having an effect on the attitudes. As also mentioned earlier, lack of proper infrastructure and the unavailability of technical support could have an impact in teachers' attitudes, and as such, these factors might nullify differences in AR adoption perception among different disciplines.

C. Theory Discussion

The results of this study are consistent with CLT, that the educational environment enhanced with AR technology helps the learner in retrieving and remembering information, which reduces the cognitive burden on them [32]. In order to raise the learning abilities, it is necessary to reduce the burden

through AR by engaging learners' various senses [33]. This has been proven to be effective in attracting students' attention, summarizing information, and presenting it in a smooth, flexible, and enjoyable way [34]. Additionally, it enhances students' interaction with the educational material, and the lower the cognitive load is, the better the performance [19]. Unlike traditional methods, which often rely on static resources and linear presentations, AR provides dynamic, interactive, and context-rich experiences that simplify complex concepts and promote deeper understanding [34]. Features like 3D visualizations and immediate feedback improve self-paced learning, which traditional approaches may lack. Although AR may initially cause cognitive overload due to its novelty, its long-term benefits, such as enhanced engagement and practical application, outweigh these challenges [35].

VI. Conclusion

This study explored pre-service teachers' attitudes and inclinations toward adopting AR in their future teaching practices. It found a clear trend toward accepting and anticipating AR technology's implementation in education. The study investigated teachers' inclination to use technology in their specialization, revealing no significant differences. Additionally, there was no statistically significant difference in the intent to use AR by level or area of teacher preparation, suggesting equal and continuous training across all levels and areas. General course training had little effect on inclination, emphasizing the importance of ongoing training opportunities. Integrating AR technology into education and training programs requires developing updated curricula and providing necessary resources and tools.

The study also revealed that teachers face several obstacles to using AR technology in education, including lack of experience and resources. Efforts should focus on providing training and technical support to overcome these obstacles and fully leverage AR's benefits. Investing in updated curricula, training programs, and resources is crucial for integrating AR effectively. Overcoming time and technical limitations is essential to maximize AR's potential in education. Institutions should invest in resources to make AR teaching easy and efficient, addressing time constraints as a barrier.

Despite insightful results, this study has two major limitations. First, the small sample size affects quantitative analysis. Thus, these findings should be used for indication, not generalization. We mitigated this by conducting follow-up interviews. Second, only teachers from two specializations were included, which may not represent the entire teacher population. Teachers in other specializations may be motivated differently and use AR differently.

In the future, his study could be improved by including a larger sample of pre-service teachers and teachers from various specializations. Future studies should involve larger and more diverse samples to provide broader insights into factors influencing pre-service teachers' attitudes toward AR. Exploring different specializations may reveal discipline-specific motivations or barriers to adopting AR technology.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Marwan M. A. Abualrob formulated the research questions, conducted the data analysis, and played a crucial role in interpreting the data, ensuring the statistical methods were applied and reported accurately. He also contributed to the discussion of the study findings.Raghad Frehat collected the data, wrote the introduction and literature review, discussed the study findings, and contributed to the preparation of the final paper. Mexhid Ferati reviewed the study findings, prepared the final paper, and ensured all sections were cohesively integrated and well-articulated. He also checked the language, improved the tables, and prepared the figures. All authors approved the research intent, discussed all parts of the final version, and collectively ensured the manuscript met the standards for academic publication.

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