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Students’ Awareness of Augmented Reality Adoption in Saudi Arabia Universities

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Full Paper

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Abstract

Technology has introduced new tools, such as Augmented Reality, in the education realm to improve learning outcomes. Augmented Reality incorporates digital information within the user's real environment. This will result in new educational opportunities by enhancing the learning experience. This paper is a preliminary study to assess students' awareness of Augmented Reality adoption in the universities of Saudi Arabia. The data collection for this survey was conducted by means of a quantitative survey using a questionnaire. The study was conducted with a sample of 501 students. Exploratory factor analysis was applied to determine factors related to students' awareness of adopting Augmented Reality in higher education. Two factors were retrieved: perceived usefulness and perceived pedagogical value.

These findings will assist in identifying factors that will encourage the adoption of AR in Saudi Arabian universities. This study is limited to AR awareness. In future, further studies will address other themes that emerged from the survey.

Keywords Augmented Reality, awareness, Higher Education, Saudi Arabia Universities

1 INTRODUCTION

The development of smart technologies has brought about significant changes in the education domain, specifically in relation to the methods used for teaching and learning. Many emerging technologies offer real pedagogical benefits which can be integrated by higher education institutions wishing to improve their students' education experiences and learning outcomes. Humans and computers can interact with each other via Augmented Reality (AR) within intelligent environments in realistic settings. In the past, many issues arose around the success or otherwise of learning outcomes, giving rise to questions about the effectiveness of traditional teaching and learning methods, and demands for new ways of teaching and learning have increased. Hence, with the increased role of computers in daily activities, several technology systems are expected to be integrated into the learning environment. The potential benefits of new innovations in education, such as AR and VR, will lead to new educational opportunities in learning and training, particularly since the younger generations are interested in technological developments and innovations.

However, despite the advancements in technology, most students are still taught by means of traditional teaching methods (Shirazi and Behzadan 2015). However, the integration of a new technology such as AR into existing courses could be a concern because the immersion of students in technology can lead to their becoming frustrated with the technology itself, preventing them from learning. Thus, it is important to know what students think about the use of innovative technologies in the learning process (Bostock 1998). McKinnon and Igonor (2008) reported that learning in a face-to-face environment is completely different from learning in an e-learning setting (McKinnon and Igonor 2008). Students' opinions need to be examined in order to facilitate the integration of AR technology and provide useful guidelines for the development of AR in university settings (Chiang et al. 2008). Thus, in this study, awareness of AR as a learning method will be examined and assessed in the context of Saudi Arabia's higher education sector.

This study aims to identify students' awareness of AR adoption for the purposes of teaching and learning in Saudi Arabian universities. This paper has been organized as follows. Section 2 reviews the extant literature on the use of AR in education and describes the Saudi education system. Section 3 presents the research questions and outlines the research method. Section 4 gives a detailed description of the data analysis and results. A discussion of findings is presented in Section 5. This is followed in Section 6 by conclusion, an acknowledgement of the research limitations and the anticipated future work.

2 LITERATURE REVIEW

This section reviews the literature from various sources related to the use of AR in education and current Saudi education system.

2.1 AR implementation in education

In their attempts to design AR learning environments, researchers have created a variety of instructional and learning approaches and applications. AR has been recognized as an effective technological method for improving students' understanding of environmental science (Hsiao et al. 2012). The implementation of AR in education settings can support students at a personal level, developing both their motivation and engagement (Squire and Klopfer 2007). Research on the utilization of AR tools in science laboratories highlights the fact that AR enhances students' laboratory skills and helps to establish students' positive attitudes to physics (Akçayır et al. 2016). The effectiveness of AR technology in higher education was exemplified in a study by Küçük et al. (2016). They found that tertiary students' academic achievements and low cognitive loads resulted from the integration of AR applications into the teaching of undergraduate medical students (Küçük et al. 2016). In that study, 79% of the students agreed that AR facilitated their learning of the topics. The enhancement of students' learning outcomes in terms of motivation, learning achievement, engagement, satisfaction, and attitude are some of the advantages of using AR in education, based on the findings of most studies (Di Serio et al. 2013; Estapa and Nadolny 2015; Ferrer-Torregrosa et al. 2015; Küçük et al. 2016). In addition, technology awareness is considered an essential precondition for adopting new technology. The first stage in the technology integration process is related to the awareness of a new technology; this can influence user perceptions and adoption intentions (Rogers 2003). Furthermore, lack of awareness of the need for AR in academic settings has led to a reluctance to implement AR in educational settings (Shelton and Hedley 2002).

2.2 Affordances of AR for teaching and learning in higher education

AR is widely used in both formal and informal learning environments for educational purposes across subject areas because of the various affordances AR can provide for pedagogical scenarios (Dunleavy et al. 2009; Wu et al. 2013). The affordances of AR technology and portability could be used to coordinate study activities in which students communicate with each other and with their real environment (Cheng and Tsai 2013). Research on the advantages of using AR as a teaching and learning tool was conducted recently by Sirakaya and Kiliç Çakmak (2018) who found that AR technology reduces mental effort and mental load, supports authentic learning, and develops students' creativity. Several authors (Bujak et al. 2013; Cheng and Tsai 2013; Dunleavy et al. 2009; Radu 2014; Wu et al. 2013) have pointed out that AR has potential educational affordances that are particularly useful in the fields of science, technology, engineering and mathematics (STEM), including theoretical understanding, scientific inquiry, spatial skills, and practical skills. Also, learner interaction, collaboration, cultural exploration and digital story-telling are other affordances offered by the AR technology in higher education (Faith 2019).

2.3 The Saudi education system

Ramady (2010) claims there is a major issue in the Saudi Arabian education system, which is related to the way that the high social prestige of obtaining a university education drives university attendance, while at the same time being the cause of a decline in the importance of vocational and technological education. According to Alnassar and Dow (2013), learning and teaching in Saudi Arabia's higher education sector has several challenges: the current curriculum does not appropriately support students' critical thinking; development and improvement of teaching methods are not encouraged; there is a lack of adequate training and workshops for faculty members and teachers; self-learning is not encouraged; and problem-solving skills are not taught (Alnassar and Dow 2013).

However, Saudi Arabian universities are making a huge effort to overcome these challenges by developing more contemporary curriculum and integrating advanced technological teaching facilities (Smith 2013). The Ministry of Higher Education in Saudi Arabia is continually conducting studies and research to improve the education sector and develop an adequate e-learning infrastructure. Teaching methods and teachers' performance have also been targeted for development by the Ministry of Education via the establishment of twenty-seven technical centres (Amoudi and Sulaymani 2014). To the best of our knowledge, none of the articles which have been reviewed so far has covered AR awareness in Saudi Arabian universities.

3 RESEARCH QUESTIONS AND METHODOLOGY

This study attempted to determine students' awareness of AR adoption for the purposes of teaching and learning in Saudi Arabian universities. The research question of this study is: What is students' awareness of the adoption of augmented reality in Saudi Arabian universities? The online survey was generated and developed based on the current literature review. Data for this research was collected by means of Qualtrics Survey Software through the following channels: emails, LinkedIn, Facebook, Twitter and WhatsApp. The target audience for this survey comprised undergraduate students in three publicly-funded Eastern Province universities in Saudi Arabia. The researcher asked the participants to record their responses to items related to AR on a scale of 5, ranging from 1 for "strongly disagree" to 5 for "strongly agree". A five-point Likert scale from "strongly disagree" through to "strongly agree", with the neutral point being "neither agree nor disagree", was selected in order to increase the quality of responses and to avoid respondents' confusion due to the volume of information in the questionnaire (Devlin et al. 2003; Revilla et al. 2014).

Scaled-response questions were asked to determine respondents' awareness of AR technology as a teaching and learning tool. These questions also used the five-point Likert scale and matrix of choice format. PhD supervisors pre-tested the questionnaire to ensure face validity. An adequate number of experts, academics, and lecturers in the education and technology domains were asked to administer and review a pilot test. The pilot test respondents were requested to provide feedback by thinking aloud as they answered the survey questions. The Statistical Package for Social Sciences IBM SPSS Statistics (version 25) was used for analysing the data and employing exploratory factor analysis (EFA) for statistical testing. Only one section of the survey, that which explored students' awareness regarding the adoption of AR technology in Saudi universities, is discussed in this paper.

4 RESULTS

This section presents the outcomes of the analysis of the survey data obtained from students. The Statistical Package for the Social Sciences (SPSS v. 25) was used for the data analysis, involving several statistical tests and methods. EFA was applied to identify the factors related to awareness about the adoption of AR in Saudi higher education. The findings are explained later in more detail.

4.1 Descriptive Statistics: Demographics

Five hundred and one students studying at Saudi universities were recruited for this study. Of the initial cohort of 501 students, 274 (or 54.7%) were male and 227 (or 45.3%) were female (see Figure 1).

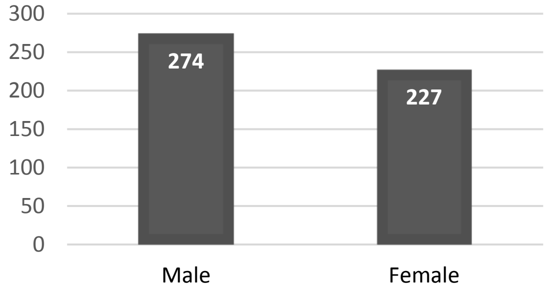

Figure 1: Participants' gender

Most of the students (88.6 %) were aged between 18 and 23 at the beginning of this study. Around 38 (or 7.6%) of them were between 24 and 28 years old. Fewer than fifteen of the respondents were between 29 and 33 years old. Only 5 (or 1 %) of respondents were between 34 and 38 years old and none was over 40. Table 1 shows the ages of participants.

	Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
18–23	444	88.6	88.6	88.6
24–28	38	7.6	7.6	96.2
29–33	14	2.8	2.8	99.0
34–38	5	1.0	1.0	100.0
Total	501	100.0	100.0	

Table 1: Participants' ages

4.2 Descriptive Statistics: computer experience level

In response to the question on computer experience, most students (56%), both males and females, claimed to have an intermediate level of experience and 28% of student participants claimed to be advanced in using computers, while only 8% indicated they had a beginner level of computer experience. When these results are compared between genders, it is apparent from Figure 2 below that more females than males are advanced in computer experience.

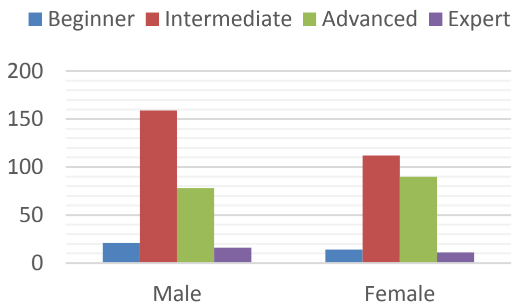

Figure 2: Computer experience levels based on gender

4.3 Descriptive Statistics: level of interest in technology

Furthermore, respondents were asked to indicate their level of interest in technology. The overall response to this question was very positive. Most students in SA universities are interested in new technologies, and approximately half of the respondents (48%) had a strong interest in technology while the other half (47%) expressed a medium level of interest. A small number (20 or 4%) of students indicated a low level of interest in technology. Figure 3 provides an overview of students' responses in regard to their interest in technology.

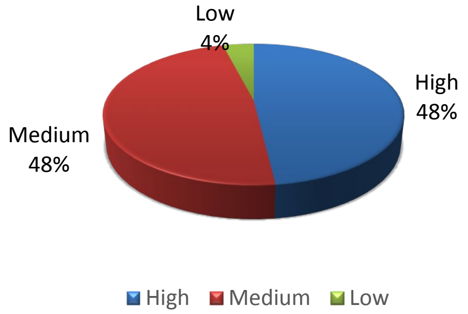

Figure 3: Students' interest in technology

As can be seen from Table 2, the male students reported greater interest in technology (50%), than did the female students.

		High	Medium	Low
Gender	Male	138 (50.4%)	130 (47.4%)	6 (2.2%)
	Female	103 (45.4%)	110 (48.5%)	14 (6.2%)

Table 2: Interest in technology based on gender

Additionally, 65% (or 329) of the student participants are aware of and very conversant with AR technology because of their daily experiences of this technology in a multimedia mobile application (Snapchat) or through the popular location-based AR game Pokémon GO. Figure 4 demonstrates the numbers and percentages of participants who had prior knowledge of AR.

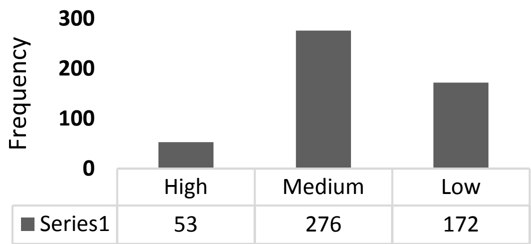

Figure 4: Participants' understanding of AR

4.4 Descriptive statistics for students' awareness of AR

Regarding what students' awareness of the AR method of teaching and learning might be, compared with traditional methods, participants were asked to indicate their level of agreement with 15 statements to determine their level of awareness. Participants' responses were gauged using a Likert-type scale anchored by five points: 1= SD (Strongly disagree), 2= D (Somewhat disagree), 3= N (Neither agree nor disagree), 4= A (Somewhat agree), and 5= SA (Strongly agree). Descriptive statistics were employed to analyse the data in this section. Participants' responses were revealed by calculating the mean of each item, and the standard deviations. This study indicates that students at SA universities are very aware of AR technology in education (M=4.00, SD= 0.901).

Items		Mean[1]	Std. Deviation
1	AR is expected to achieve intended use	3.92	.816
2	AR is much better than traditional learning method	4.01	.981
3	AR is suitable for different ages	3.77	1.090
4	AR is suitable for different genders	4.25	.875
5	AR is appropriate to apply in various subjects	4.14	.826
6	AR saves time and effort for the teachers and students	4.17	.902

[1] The scale was: 1=SD, 2=D, 3=N, 4=A, 5=SA.

7	AR will assist in learning and teaching	4.23	.832
8	AR will help improve learning outcomes	3.84	.884
9	AR meets my satisfaction and goals	3.81	.907
10	AR as a learning tool will increase my learning performance	3.98	.913
11	AR will promote self-learning	4.00	.910
12	AR takes less time to deliver the information	3.93	.992
13	AR as a learning tool is engaging	4.00	.891
14	AR is a cooperative learning tool	4.00	.861
15	AR will assist my learning efficiency	4.02	.839

Table 3: Descriptive statistics for AR awareness items

As Table 3 above shows, statements 4, 7, 6, and 5 produced the highest means for student awareness. Statement 4, "AR is suitable for different genders" has (M= 4.25, SD= 0.875); statement 7, "AR will assist in learning and teaching" has (M= 4.23, SD= 0.832); statement 6, "AR saves time and effort for the teachers and students" has (M= 4.17, SD= 0.902); and statement 5, "AR is appropriate to apply in various subjects" has (M= 4.14, SD= 0.826). The lowest frequently mentioned awareness was in relation to statement number 3, "AR is suitable for different ages" (M= 3.77, SD= 1.090). Table 4 gives the means and standard deviations for students' awareness of using AR technology in SA higher education. Means and standard deviations of all the items were computed for male and female students to determine any differences in their awareness of AR. No significant differences were found between male and female awareness of AR technology as a learning method. The mean score for the female students' awareness was 4.01 while the mean score for the male students was 3.99. The results obtained from the preliminary analysis of students' awareness, based on gender, can be compared in Table 4.

		Average mean	Average std. Deviation
Gender	Male	3.99	0.86
	Female	4.01	0.94

Table 4: Descriptive Statistics for AR awareness based on gender

4.5 Students' awareness results – Exploratory Factor Analysis

EFA was established since the KMO value was .899, which is above .7. The Bartlett's Test of Sphericity (Bartlett's Test) is significant at p ($p < .001$) (see Table 5), indicating that factor analysis could be conducted.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		**.899**
Bartlett's Test of Sphericity	Approx. Chi-Square	2818.932
	df	105
	Sig.	.000

Table 5: KMO and Bartlett's Test – Students' Awareness of AR

From fifteen dimensions, two factors were retrieved according to the eigenvalue rule, where only those factors with an eigenvalue of ≥1 are generated by using the PCA method. These factors contributed 38.91% and 11.44% of the total variance respectively (cumulative value of 50.35%). More specifically, the first factor shows the highest variance, followed by the second factor. In addition, the Scree test technique was used to support this result (see Figure 5). It demonstrates factors above the inflection point (elbow).

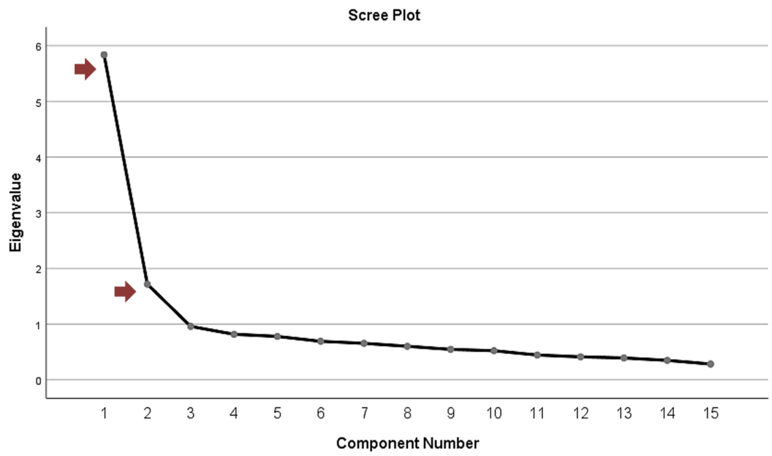

Figure 5: Scree plot of Student Awareness of AR

The Varimax method was used to rotate the data. Hair et al. (2010), stated that labelling the factor would be impacted by higher loading variables (Hair et al. 2010). Furthermore, the objective of the factor analysis is also considered in the selection of factor names. Therefore, these factor names were selected based on the basic purpose of the analysis and the items that are highly loaded inside them. Cronbach's alpha for the 15-item scale (α = .876) demonstrates high internal consistency. The EFA of the 15 items under awareness revealed two factors. Variables loading on the first factor all relate to the usefulness of AR in education. This was labelled 'perceived usefulness'. The second factor contains four items related to the pedagogical contributions of AR technology to learning and teaching. It was labelled 'perceived AR pedagogical contributions. After several steps, one item was removed due to cross loadings of .3 or above. The factor loadings and Cronbach's α are summarized in Table 6.

Factor Label		**Factors**	
		Factor 1	**Factor 2**
Perceived usefulness	AR is suitable for different genders	.737	
	AR saves time and effort for the teachers and students	.721	
	AR will assist in learning and teaching	.715	
	AR is suitable for different ages	.679	
	AR is much better than traditional learning method	.646	
	AR is appropriate to apply in various subjects	.640	
	AR will help improve learning outcomes	.589	
	AR will promote self-learning	.560	.359
	AR is expected to achieve intended use	.549	
	AR is a cooperative learning tool	.485	
Perceived AR pedagogical contribution	AR meets my satisfaction and goals		.770
	AR will increase my learning performance		.756
	Augmented reality as a learning tool is engaging		.751
	AR will assist my learning efficiency		.747
	AR takes less time to deliver the information		.646
	Cronbach's α	**.849**	**.812**

Table 6: Factor loadings and Cronbach alpha for Student Awareness of AR items

In this study, the internal consistency for the survey instruments using the alpha coefficient was 0.876, which is almost consistent. Factors and the reliability statistics of the survey dimensions are shown in Tables 6 and 7.

Factor labels	Number of items	Cronbach's α	KMO
Perceived usefulness	9	.849	.892
Perceived AR pedagogical contributions	5	.812	.808
Total	14	.876	.899

Table 7: Cronbach´s Alpha and KMO for the factors of Student Awareness AR.

5 DISCUSSION OF FINDINGS

The aim of this study was to identify the extent to which students were aware of the benefits of using AR to improve learning and teaching in Saudi higher education institutions. As mentioned in the literature review, awareness of a new technology must be considered in the first stage of the technology integration process, as it can influence user perceptions and adoption intentions (Hamidi and Chavoshi 2018; Khan et al. 2015; Kukulska-Hulme and Traxler 2007; Rogers 2003). In the Middle East, most universities are aware of the application of technologies for learning. However, it was considered important to conduct awareness studies in other institutions before taking further steps toward adoption (Alharthi et al. 2017; Mohamed et al. 2014). The findings of this study illustrate that two factors of students' awareness of AR benefits in education (perceived usefulness factor and perceived AR pedagogical contributions factor) have been retrieved using EFA sample data sets (n=501) of students from universities in Saudi Arabia, as seen in Figure 6. The findings of this research were considered in relation to gender. The results indicated that male students rather than females are inclined to be more interested in technology. Based on the results, students are aware that the implementation of AR in higher education can have several benefits in terms of improving learning and teaching in Saudi Arabian universities. A review of the findings of this study indicates that there are no statistically significant differences between males and females in regard to their awareness of the benefits of AR.

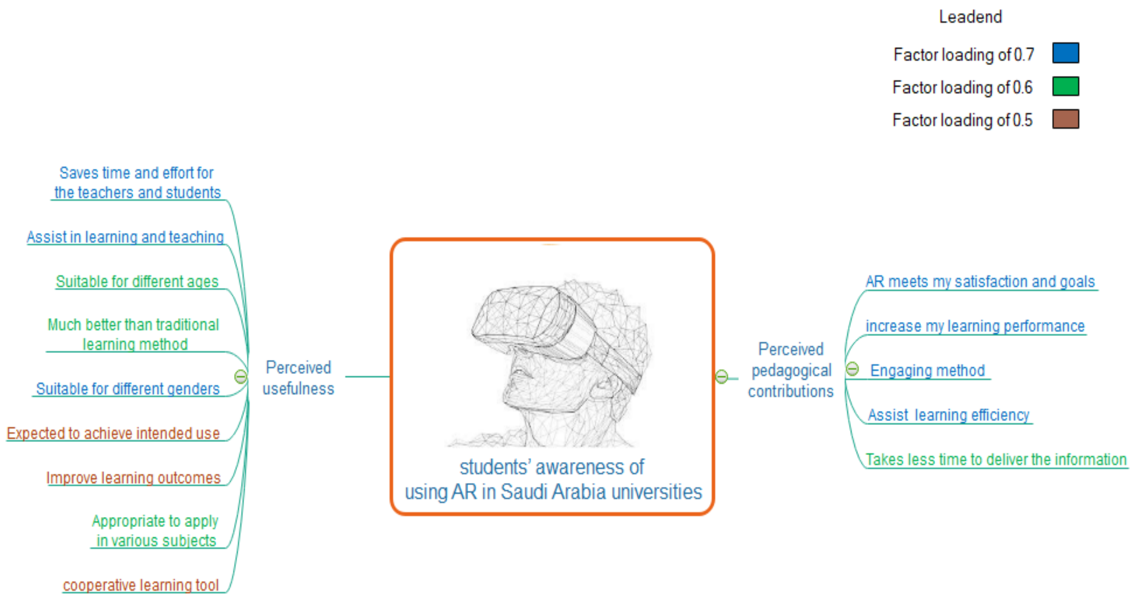

Figure 6: Factors related to students' awareness of AR in Saudi Arabian universities

5.1 Perceived usefulness factor

Factor one is related to technology usefulness, which includes several dimensions (n= 9) (see Table 6). The current study found awareness among students because they considered that AR technology would be valuable in higher education. They believed AR to be useful for different disciplines by as it saved time and effort for the teachers and students, allowing them to do things that they could not easily do using traditional learning methods. AR was also found to be useful for learning and teaching practices, regardless of student gender and age. This finding corroborates the findings of similar studies that explored the perceived usefulness factor for the adoption of AR in education (Tsai et al. 2010; Yuan-Jen et al. 2011) and suggests that this factor is pivotal in determining people's intention to integrate a particular system.

5.2 Perceived pedagogical contributions factor

Factor two concerns the perceived pedagogical contributions of AR technology dimensions. This was found to be an important contributing factor, accounting for several dimensions. It includes concepts such as satisfaction, learning performance, engagement, learning efficiency, and less time to deliver the information. Participants believed that AR in education could meet their expectations and goals, giving this measurement a rating of 0.770. This leads to the potential for better learning performance (.756), thereby enhancing learning efficiency. This is in line with the findings of Dalim et al.'s (2017) study of factors influencing the acceptance of augmented reality in education. Dalim et al. (2017) found that participants have a greater acceptance of AR in education because they recognise its pedagogical value. In this study, many respondents expressed awareness of the pedagogical contributions of AR, which might facilitate the integration of AR in SA higher education. It is also important to raise awareness of AR pedagogical values in order to facilitate acceptance when introducing AR as an innovation in higher education. The main, new contribution of this study is that it shows that students have a strong awareness of the usefulness and pedagogical contributions that AR can offer to education, as demonstrated by the statistical data. Therefore, this study will help faculty members, university administrators, e-learning planners and other stakeholders to understand the level of students' awareness when considering the adoption of new technologies such as AR learning tools.

6 CONCLUSIONS, LIMITATIONS AND FUTURE WORK

This study was intended to identify the awareness of students regarding the implementation of AR technology in universities in Saudi Arabia for the purposes of teaching and learning. The results of the quantitative analysis in this study indicate that, in general, while one objective is to improve learning outcomes in Saudi Arabian higher education, and to achieve the objectives of the Saudi Vision 2030, integrating innovative learning approaches such as AR and VR in the higher education system will benefit students' outcomes in Saudi higher education. The online survey conducted with Saudi undergraduate students examined their awareness of the potential benefits offered by the adoption of AR in higher education. From the fifteen items under "AR adoption awareness", two factors were extracted, namely perceived usefulness and perceived AR pedagogical contributions factors. This study confirms that there are positive expectations and awareness of the adoption of AR in education as a useful learning tool that provides students and teachers with several pedagogical benefits. This study provided a good understanding of students' positive intentions to use AR technology in the learning process in higher education.

It was difficult for the researcher to find data from an exploratory source because AR is still a new technology and some of the participants were not familiar with it. The current study was limited to examining participants' awareness in terms of adopting AR technology in higher education and sought the opinions only of students in the SA higher education sector. Future research could obtain the opinions of academics and e-learning staff and use this data to make effective use of AR technology. As this is ongoing research, further study is needed to identify the effectiveness of this technology compared with the traditional learning methods of Saudi students in higher education.

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