Exploring the Influential Factors Affecting Staff Willingness to Adopt Augmented Reality

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***Abstract*—Adopting modern learning technology such as Augmented Reality (AR) technology in higher education has become a demand to enhance teaching and learning performance and motivate students to acquire effective learning processes. Yet, the readiness of universities to adopt modern learning technology, such as AR applications, in developing countries, particularly in Saudi Arabia, is considered one of the critical issues to ensure the AR system's success. This study aims to explore the factors that influence the academic members' willingness in Saudi Arabian higher education to adopt modern learning techniques such as AR technology. To test the model, a quantitative survey using a questionnaire with a five-point Likert scale was applied in this study to collect the data. The study was conducted among a sample of 228 academic members and e-learning staff. Based on the analysis, the study found that perceived usefulness and perceived pedagogical contribution are important predicting factors for academic members' willingness to employ AR in Saudi Arabian higher education teaching. The findings from this study provide insights that assist further studies regarding AR integration factors in higher education. This study contributes to the literature by developing a theoretical and conceptual framework of critical success factors for AR incorporation in Saudi Arabian (SA) universities.**

***Index Terms*—Modern learning technology, Augmented Reality, Saudi Arabia, higher education**

I. INTRODUCTION

In the past few years, many emerging technologies have received increased attention. The various potential uses of emerging technologies continue to improve educational, medical, and business practices. The efficiency of these tools motivates their implementation in the academic setting [1]. Many educational facilities, for instance, implement Augmented Reality (AR) to enhance conventional teaching strategies [2]. AR permits more natural interactions between people and virtual objects in the real environment [3]. Recent studies have focused extensively on AR. According to Vogt and Shingles [4], "AR is an emerging concept, but it is now transitioning to a more firmly established technology." The global education system has been drastically altered by COVID-19, and technologies have been utilized in innovative ways to enable schools to continue teaching. Practical education in higher education settings can benefit from the adoption of innovative technologies, for instance, AR during the COVID-19 epidemic [5]. Similarly, Krishnamurthy [6] proposes AR as a means to improve remote teaching by providing a more engaging and interactive experience for students during the required isolation period [7, 8].

However, the optimal integration of technology into classrooms has not yet been accomplished. It is for this reason that studies examining the issues impeding the widespread use of ICT to implement the desired improvements in educational outcomes are more common [1]. In particular, the conceptual foundation for its usage and integration into education is crucial to the success and future integration of digital learning efforts in the educational context [9–11]. Although a number of studies indicate critical elements for the adoption of these technologies [9, 11], there has been minimal research on incorporating AR into classrooms [12, 13], particularly in developing nations such as Saudi Arabia (SA). In its 2030 vision, SA's government places significant emphasis on the development of the higher education system. The government's vision also intends to ensure that technology is an important part of the university's educational goal and that the university is internationally recognized and ranked [14]. However, the delayed adoption of AR in SA higher education may be attributable to the absence of a complete standard set of AR incorporation factors in educational contexts [15, 16]. Furthermore, there is little to no direction on how to integrate AR applications at the university level, and the influential variables of AR integration remain largely unexplored in KSA universities. Most research examining AR in schools [17–19] has assessed the level of satisfaction experienced by students and educators. The findings of these studies show extremely high levels of satisfaction and positive evaluations. Fusing AR with educational materials can create novel, fully-automated applications that improve both the quality and quantity of students' and teachers' experiences in the classroom. Another study had used Augmented Reality (AR) applications in the classroom to teach electrical engineering and help students to learn more independently [20]. The results showed that AR helped students learn on their own and reduced the need for repeated explanations. Also, Akçayır and Akçayır [21] showed that most benefits related to using AR in education concern how students learn, such as their motivation, attitude, and learning outcomes.

AR includes a variety of innovative new technologies that can improve learning outcomes. AR technology facilitates the learning environment by integrating students' digital materials into the actual environment [1]. The possible educational advantage of AR is reviewed by Munnerley and Bacon *et al.* [22], who recommends that proper educational AR applications be implanted within a larger framework that identifies how learning occurs, using AR to encourage questioning critical thinking, reflection, and collaboration. Most research shows that AR in education improves

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students' motivation, learning outcomes, engagement, satisfaction, and attitude [23–25]. Different affordances of AR could allow for several pedagogical scenarios, resulting in widely-ranging uses of AR for both formal and informal education in various fields [26]. Therefore, the main goal of this study is to determine the factors that influence the faculty member's willingness to integrate modern learning technology, specifically AR, into higher education.

II. Literature Review

Educators and teachers continually search for new technologies, tools, and approaches to advance learning, encourage self-learning, and impel students to actively engage in their own learning. To assist the interpretation of how and why colleges reject or accept technology and to track behavior in different implementations, numerous models have been devised and modified from various theories and fields [1]. Some of these theories have their roots in the field of information systems, e.g., the Technology Acceptance Model (TAM) [27] and Unified Theory of Acceptance and Use of Technology (UTAUT) [28]. Technology acceptance has been defined by Louho and Kallioja *et al.* [28] as how individuals are, receptive to, and able to make use of new technologies. Models are used to encourage people to adopt new technologies. Studies [18, 29–31] have been performed to examine what makes users more likely to accept and use an AR system in learning environments that use TAM. Wojciechowski and Cellary [18] indicated that, the TAM was critiqued by several studies for the following reason: "the omission of intrinsic factors that influence computer acceptance." According to Balog and Pribeanu [30], one of the most important factors in determining whether or not a user truly utilizes AR for educational purposes is how much fun they perceive can be gained from the technology. Almaiah and Alhumaid *et al.* [32] stated that, to promote the adoption of modern learning systems, institutions should examine critical variables such as IT infrastructure, awareness, university management support, and university culture. Although developed theories are commonly used in information system research, some models have been established to use educational AR and present a variety of AR implementation factors. Thus, most of these frameworks and models have concentrated on the development, efficacy, acceptance level, technological challenges, initial implementation of AR, and usability. No model has addressed both the instructional component and certain technological features such as usability. These frameworks and models and cannot be adopted and utilized in university context in SA due to significant variations in existing conceptualizations of AR in higher education that hinder their adaption in developing nations such as SA; few studies have examined the personal and technological variables that could facilitate the incorporation of AR into higher education, particularly in developing nations [32–35]. Adopted models and theories, when employed independently, might not provide enough information about the investigated area [36]. Therefore, the model cannot outline aspects that would motivate the systems' success or failure in integrating AR technology in the context of developing countries and universities. This justification indicates the importance of examining factors affecting faculty members' use of AR in the learning process.

A. Willingness and Other Factors

The literature underlines that launching an AR system in colleges necessitates technological personal willingness and readiness in order to develop a feasible plan [37]. Willingness is a key aspect in determining whether or not a technology can be successfully applied. Devlin and Dong *et al.* [38] asserts that both teachers and students need to be willing to adopt and employ AR technology as a teaching and learning approach. According to certain pieces of research, the readiness to integrate and incorporate innovations into learning practices is crucial for academic performance [39]. Therefore, higher education must raise awareness, provide resources, and organize workshops to prepare for AR.

Previous research has highlighted the significance of perceived utility and its importance in incorporating technologies such as TAM [27]. When technology is perceived as useful, users are more likely to have a positive attitude toward it, which influences their intention to use it and how it is used [40]. Interestingly, perceived usefulness is cited as a substantial role in the learning of students utilizing AR technology in various research projects [18, 41]. According to Cheng [42], even though AR has made significant progress in raising the level of learning and innovation, few are aware of how useful it can be in the education field. AR's perceived utility was discovered to prompt its use as a pedagogical tool. According to Wang [43], the perceived usefulness of AR affects the intent to employ AR in education. Potential users' intentions to use AR technology are influenced by how simple it is to use, how beneficial it is, and how potential users feel about the application [44]. In literature, perceived usefulness is advised to foster the implementation of educational AR [44, 45]. Consequently, the following hypothesis was formed:

H1: Perceived usefulness has a positive influence on willingness to use AR.

Perception-related important success variables were determined through a review of the literature. This review included understanding the pedagogical advantages and disadvantages of technologies in education, as well as their applicability to pedagogical designs and plans [46, 47]. As Topper [48] discussed, "for teachers to use technology in support of their teaching, and to see it as a pedagogically useful technology, they must be confident and competent with the technology they are planning to use." According to Ertmer and Ottenbreit-Leftwich [49], integrating technology effectively into the classroom requires an acknowledgment of the pedagogical perspectives and beliefs of teachers. Experts in the field of higher education were surveyed using quantitative methods to determine their perspectives on the use of educational technologies like AR [50]. A lack of perceived pedagogical benefit hindered the use of AR for learning and teaching in higher education. Five critical factors, including pedagogical beliefs, self-efficacy, teacher knowledge, school culture, and subject, were identified by Ertmer and Ottenbreit-Leftwich [49] as having a significant impact on technology integration and utilization. Tondeu and Aesaert *et al.* [51] found that teacher-perceived pedagogical values may hinder technology utilization in education. The finding aligns with the [52] study of factors impacting AR acceptability in learning, which finds that respondents have favorable opinions regarding educational AR due to its pedagogical contribution; the unique pedagogical ability of AR may boost its use in education. Moreover, this finding is consistent with the findings of Tondeu and Aesaert *et al.* [51], which demonstrated that pedagogical views concerning innovative technologies may impede their integration into education. Therefore, the following hypothesis was formed:

H2: Perceived pedagogical contribution has a positive influence on willingness to use AR.

According to the literature, the design and usability of AR applications are crucial influences on the effectiveness of AR in education [22]. Design and usability, or user rejection risk, must also be considered in technology adoption [26]. Venkatesh and Morris *et al.* [27] suggests that system acceptability depends on perceived ease of use. Furthermore, user experience, such as enjoyment, affects behavioral intention to use a system [21]. According to previous studies [53, 54], perceived usability indirectly influences users' propensity to adopt AR in learning. Pérez-LÓPez and Contero [55] argues that system usability must be evaluated when adopting any innovative technology to deliver an effective learning and teaching experience with AR. In the AR implementation early phases, interacting with the system presents a number of impediments and challenges; nevertheless, these will be eliminated, and the system will eventually be enhanced. AR's future integration depends on how easy it is to use. Similarly, Tao [56] found that AR apps and functionality must be made more user-friendly. The literature strongly supports the idea that AR technology design should guarantee usability. According to Rasimah and Ahmad *et al.* [57], AR applications' usability must be improved to attract consumers. Furthermore, because AR fundamentally offers a novel experience, the introduction of easy-to-use technology allows for new users to access the technology [51, 56–58]. Taha and Abulibdeh *et al.* [59] examined students' perceptions concerning AR technologies. The research showed that AR acceptability depends on perceived ease of use. Thus, the following hypothesis was formed:

H3: Usability has a positive influence on willingness to use AR.

III. Method

This research aimed to determine the factors that could enhance the willingness of faculty members to adopt innovative educational approaches such as AR into higher education in Saudi Arabia, particularly in universities. A descriptive study design was adopted through the use of a survey questionnaire. For this purpose, the researcher used Qualtrics, a web-based survey tool, to conduct the online survey for data gathering. The study population comprised lecturers and e-learning staff in three public universities in Saudi Arabia. The universities were selected because they are in the same geographical region and offer several faculties, including engineering, medicine, science, etc., which are deemed to be highly regarded subjects of study for both male and female students. Additionally, the universities' teaching methods are varied and include computerized methods, technology usage, and virtual learning, which are consistent with the objectives and nature of the study. More specifically, the study included 228 participants, selected from the academic and e-learning department staff, to whom survey copies were distributed. To collect the data, the researcher contacted these universities. Each institution has an ICT communication center where all academic personnel can be reached. The researcher was authorized to provide these universities' communication centers with recruitment materials, including a URL to email the sample group, after receiving ethics committee approval to disseminate the survey questionnaires. The researcher distributed survey questionnaires with recruitment materials, including hyperlinks, to the sample population. The researcher sent follow-up communications to participants for a week following the distribution of the copies. Three follow-up communications within a three-month period were not sufficient to generate high responses from the e-learning staff and academics, as such, survey copies were also forwarded to other potential respondents using WhatsApp, email, LinkedIn, Twitter, and Facebook. This strategy, particularly the use of Facebook and WhatsApp, enabled the researcher to garner more responses.

Several steps were followed to develop the measurement of the study variables, the first step being the derivation of the variables from the existing literature. The items were gauged using a 5-point Likert scale that ranged from 1, denoting strongly disagree, to 5, denoting strongly agree. The Likert scale was used to reduce respondent ambiguity and improve response quality [37–39]. Issa [60] noted several benefits of using an online survey, including low costs, time-saving efficiency, and simplicity of distribution. Furthermore, online surveys give the researcher complete control over the data collection process; multiple survey forms are accessible; and the researcher can quickly remind respondents to complete the questionnaire and thank them for their participation [39]. The first section of this study's survey contained closed-ended questions concerning the respondents' demographic information (age, gender, computer experience, and level of technology interest). The second section contained scaled-response items measuring the respondents' opinions on factors that influence their willingness to use AR technology as a modern teaching and learning technology. For these items, respondents were also requested to indicate their answers on an agreement/disagreement level based on a 5-point Likert scale. This study's measurement reliability and validity were tested and confirmed in the following steps: the entire measurement items were tested for content validity through adequate experts' opinions, after which a pilot test was performed to confirm the measurement items' reliability. The pilot test was performed on a smaller sample size, and the results confirmed the clarity and understandability of the items. Based on comments from pilot test respondents and experts, some well-considered revisions were made to the questionnaire in this study. These adjustments included splitting lengthier questions into two parts for clarity and rephrasing some questions to reduce ambiguity or doubt. The survey's final version incorporated all of the adjustments. The IBM Statistical Package for the Social Sciences (SPSS) (version 25) was used to analyze the data through Confirmatory Factor Analysis (CFA) and Exploratory Factor Analysis (EFA) for statistical testing. However, the convergent validity of the measurements was tested using composite reliability (<0.50) and Average Variance Extracted (AVE) (<0.50). According to Taber [61], Cronbach's alpha has a standard value of 0.7, but values higher than 0.6 are also accepted. Table I and II contain the composite reliability, AVE values, and discriminant validity obtained, and both exceeded the minimum recommended values. When the alpha coefficient was used to measure survey reliability, the results were above 0.6, indicating high internal consistency for the academic staff, which is almost consistent. Lastly, discriminant validity was established by conducting a comparison between the AVE square root and the constructs' correlations, and based on the results (See Table III), the AVE squared values were higher than the values of their correlations.

This study will address only one section of the survey, which sought the respondents' thoughts on the usefulness, pedagogical contributions, and usability factors that could influence lecturers' and e-learning members' readiness to adopt AR technology in SA universities.

IV. Results

146 academic staff members participated in the survey, of which 89 were male and 57 were female. Academic and e-learning staff members were asked to demonstrate their knowledge of augmented reality and its educational uses. According to gender, 73.9% of the entire male sample of lecturers and e-learning personnel (or 99 out of 134) were familiar with the concept of employing AR technology in education and were eager to implement it, 84% of female lecturers and e-learning personnel (79 of 94) were knowledgeable about AR technology and had used it before. Thus, the sample was deemed eligible to provide an opinion that could add to the accuracy of the study's findings.

Table I displays the gender and AR knowledge of the participants.

TABLE I: E-Learning and Academic Previous Knowledge about AR Based on Gender

			Prior knowledge of AR			Total
			High	Medium	Low	
Gender	Male	Count	32	67	35	134
		% within gender	23.9%	50.0%	26.1%	100.0%
	Female	Count	18	61	15	94
		% within gender	19.1%	64.9%	16.0%	100.0%

The direct effects were obtained by evaluating the formulated hypotheses; accordingly, the direct path effect coefficient and effect size based on the recommendations of past studies [61] were calculated. Basically, the path coefficient values in Table IV reflect the direct relationship strength between two variables. Among the effects of the three variables, perceived usefulness and perceived pedagogical contributions had significant effects on the willingness to adopt AR technology. More specifically, Table IV illustrated that perceived pedagogical contributions obtained a path coefficient value of 0.198, with a *t*-value of 2.34, indicating support for Hypothesis 2 at $p < 0.05$. Considering usability in Hypothesis 3, the path coefficient value was found to be −0.01, with a *t*-value of 0.22, indicating no support for the third hypothesis at $p < 0.05$. With regards to perceived usefulness, the path coefficient value was 0.133, with a *t*-value of 2.22, which indicates support for hypothesis 1 at $p < 0.05$.

TABLE II: Reliability and Validity Results

Variable	AVE	CR	Cronbach's alpha
Perceived usefulness	0.578	0.843	0.755
Usability	0.578	0.844	0.757
Perceived pedagogical contributions	0.662	0.939	0.662
Willingness	0.670	0.910	0.876

TABLE III: Discriminants Validity Results

Variable	Perceived usefulness	Usability	Perceived pedagogical contributions	Willingness
Perceived usefulness	--	0.76	0.67	0.49
Usability	0.76	--	0.40	0.82
Perceived pedagogical contributions	0.67	0.40	--	0.40
Willingness	0.49	0.82	0.57	--

TABLE IV: Paired Sample T-test Results for Self-Efficacy

Hypothesis	R/ship	*T* statistics	
H1	PU-WILL	2.22**	Supported
H2	PEDA-WILL	2.34**	Supported
H3	U-WILL	0.22	Not-Supported

Note: Significant path coefficients:
* Significant at $p < 0.05$
** significant at $p < 0.01$
*** significant at $p < 0.001$

V. Discussion

This study aimed to examine the effect of perceived usefulness on the willingness to adopt AR technology, and, based on the obtained results, the effect is significant, as reported by prior studies [58, 59, 62, 63]. Perceived usefulness, based on this study, is among the topmost significant predictors of willingness to adopt technology, and this significance may be attributed to the participants' beliefs that AR technology usage can enhance the content quality of their lessons, the relevant knowledge, and the efficiency of teaching and learning. According to the obtained results, instructors with a higher awareness of the AR technology usefulness in learning are more inclined towards its use. Aligned with this, Alam and Susmit *et al.* [40] states that perceived usefulness is the topmost influential predictor of users' IT acceptance intentions and that users perceiving a benefit from using IT hold positive perceptions towards its adoption. Moreover, perceived usefulness significantly influences users' attitudes [63] and user's intention towards AR technology adoption [40]. On the basis of the

Technology Acceptance Model (TAM), perceived usefulness is among the major principles that drive the behavioral intention of individuals towards technology usage [64–67]. In another supporting study result, Rese and Schreiber *et al.* [68] reported the positive influence of perceived usefulness on behavioral intention towards AR technology adoption. Lastly, perceived usefulness was evidenced to have a higher statistically significant impact on behavioral intention to use AR teaching platform compared to other variables [30]. Hence, this study is aligned with previous studies that support the significant prediction of perceived usefulness of the participants' willingness towards AR technology adoption and, in effect, supports the formulated hypothesis.

Moreover, usability had no significant effect on the willingness to adopt AR technology: a result that is not aligned with that of prior studies [67]. Such contrasting results may be related to the lack of experiences and information concerning AR in the teachers' learning processes and the early adoption phase. These contrasting results may also be caused by insufficient information among instructors concerning the factors that facilitate the use of AR in the teaching process. Also, based on the observation of the researcher (section IV), the teachers hailed from varying fields and colleges and thus had different perceptions of and experience levels in using technology. In this study, the participants may have perceived using technology for instruction as challenging, owing to their unfamiliarity, as evidenced in previous studies [66–70]. These studies indicated that there is a correlation between usability, prior experience, and technological affinity. Additionally, teachers with positive attitude towards technology use perceived it as being easy to use and useful for teaching. This perception highlights the benefits of training in AR technology usage among teachers to improve comfort with and confidence in using AR technology in their classrooms [71–77].

VI. Conclusion

This study examined the factors driving individuals' willingness to adopt AR technology in the teaching-learning environment. These factors included perceived usefulness, perceived pedagogical contribution, and usability. A few studies have examined AR adoption in different domains within university contexts, demonstrating that faculty members understand the potential benefits of AR in higher education. However, the pedagogical aspect and certain technology dimensions that could affect the willingness to use AR have not been addressed together by any model. The present study's results support amplifying the AR model, and, based on these results, perceived usefulness and perceived pedagogical contribution appear to be the topmost significant factors influencing respondents' willingness to adopt AR technology. Surprisingly, usability did not have a significant influence on willingness to adopt the AR technology in the process of learning and teaching; reasons for this lack of influence may include participants' previous experience with AR usage and technological affinity having influenced the results.

This study's findings' future importance is predicated on Rogers' "diffusion of innovations" theory's first stage, which provides a quantitative indicator of SA faculty and universities' readiness to adopt AR. Therefore, this research aims to expand theoretical and academic knowledge of the key variables needed to adopt AR in university teaching and learning. The set of variables and their anteceding role in predicting AR technology use have not been sufficiently studied, and the existent results have been contradictory. This study used a comprehensive survey strategy to examine the topic and extend technology adoption ideas by combining a range of diverse determinants. This study also examines new variable correlations for the first time in the AR setting, which may help academics and researchers understand AR. Therefore, this study's conceptual framework and hypotheses' confirmation or rejection may lead academics and researchers to further examine the issue. Consequently, this research has major consequences for academics, higher education institution decision-makers, and researchers who are most interested in technology adoption models and their explanations, particularly AR.

VII. Limitations and Suggestions

Theoretically, the current research was needed to better understand how AR is increasingly employed in education and can be used successfully in higher education contexts in underdeveloped nations, which is a still untapped area of research. Despite the meaningful results and implications furnished by the present study, it, unlike other studies, has its own limitations. The first limitation pertains to the limited sample obtained from funded universities, which confines the generalization of results, and, in this aspect, future studies may make use of the same approach, design, and framework but extend the population to other private universities. The second limitation is related to the quantitative data collection method adopted through self-reporting, which could have had a negative influence on the participants' answers; participants may have manipulated their answers to suit the researcher's perceptions. Hence, future studies can adopt a qualitative or mixed approach to gain further insight into the perceptions of the universities' lecturers concerning AR adoption. Lastly, the study examined limited factors, which provides an opportunity for future studies to add other factors (e.g., environmental and personal factors) to the model and test their direct and indirect influence on the adoption to support the validity of the developed and proposed study model.

Conflict of Interest

The author declares no conflicts of interest.

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