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The Effect of an Augmented Reality App on a Learner's Desire to Use Electronic Resources During the COVID-19 Epidemic

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Abstract: An innovative tool in the field of e-learning, augmented reality applications help students learn more quickly inside of online classrooms. Due to the rapid spread of COVID-19, conventional methods of instruction had to be put on hold at the outset of the pandemic. In light of the recent COVID-19 epidemic in Asia, this research explores college students' perspective on online education using augmented reality software. Based on the idea of planned behavior, this research developed a conceptual model to investigate the attitudes and intentions of college students about the use of an augmented reality app for course-related e-learning. Information from 135 Asian college students was analyzed using structural equation modeling. Students' attitudes and a sense of agency over their own actions had the greatest impact on their propensity to embrace augmented reality applications for e-learning, whereas subjective norms had a very little role, as seen by the study's findings. These findings validate students' interest in and acceptance of cutting-edge education methods like augmented reality applications.

Keywords: A pandemic; augmented reality; e-learning; the COVID-19 virus

1. Introduction

The global COVID-19 epidemic has had a significant impact on healthcare, education, and economics. Starting in March of 2020, the World Health Organization will treat this virus as a global pandemic. Consistent coverage in the media shows that the COVID-19 epidemic is having a devastating effect on millions of people's lives and a broad range of economies [1]. Medical centers are taking action to halt the spread of COVID-19 and reduce the widespread destruction the virus has wrought. The global distribution of the extremely infectious COVID-19 virus is skewed toward Asia [2, 3]. As a result, the already-dangerous conditions in which children and communities found themselves were exacerbated by the lockdown of all social, economic, traveling, importing, and exporting activities, and most significantly, schools [4]. The Higher Education Commission and the Ministry of Federal Education and Professional Training of Asia issued an order to shut down all schools throughout Asia in early March 2020 as part of the government's strict safety measures [5]. Cancelling in-person classes as recommended by public health professionals helps reduce the likelihood of spreading the virus to the school's students, faculty, and support staff [6].

The purpose of UNESCO, the United Nations Educational, Scientific, and Cultural Organization, is to promote world peace and security via the dissemination of knowledge in these fields on a global scale [7]. According to a UNESCO report [8], more than 1.5 billion pupils in 165 countries were affected by the early announcement of the complete closure of schools. Universities and colleges have shifted their attention to online education in order to preserve their academic offerings. Some virtual channels (e-learning or on-air courses) have been launched by the Ministry of Education and the Higher Education Commission of Asia to enable students to keep up with their education while institutions are closed. Virtual classrooms and other forms of online communication and collaboration are being used by both public and private schools. Tools like Zoom video conferencing and Google classrooms are among those being used [9]. The relative novelty of online learning might make it difficult for some students to acquire their bearings and navigate their way through the material [10, 11, and 12]. Both students and teachers have run into serious difficulties when undertaking the course's mandatory practical experiment. E-learning seasons were far more challenging for students in STEM subjects than lab seasons, when they were obliged to physically present to do experiments in the real world. Several academics have suggested that pandemics provide a compelling opportunity to reorient institutions toward a more sustainable future by reevaluating the educational system as a whole (13, 14 and 15]. To strengthen e-

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learning and help students close any knowledge gaps they may have, schools should use novel methods. The incorporation of information and communication technologies (ICT) such as augmented reality is, therefore, essential, since it has the potential to improve the quality of e-learning and provide students access to valuable hands-on training despite the disadvantages of distance education. Augmented reality creates a one-of-a-kind interactive experience that enhances the level of understanding of virtual things by superimposing computer-simulated materials on a real-world environment in the form of 3D photographs, videos, avatars, and interactive elements.

It improves the user's interaction with a multimedia smart device (such a smartphone, tablet, or computer) to provide context-aware content. AR has been underused in the classroom despite its novelty and practicality [16]. This article claims that during the COVID-19 pandemic, the use of augmented reality software greatly enhances college students' capacity to get field experience. In light of the current COVD-19 pandemic, this study aims to help fill in some of the gaps by examining how students feel about utilizing augmented reality apps for online education. This study made use of Google Expeditions, an augmented reality program released in 2015 by Google LLC. This app's goal is to provide students and instructors with a first-person, virtual reality experience of their course material on iOS and Android smartphones. We utilized TPB to investigate students' perspectives on augmented reality apps as a tool for online education. Several authors have used TPB to investigate how students' attitudes, norms, beliefs, and intentions change when they use augmented reality apps in the classroom [17]. The perspectives of students on the use of augmented reality apps in the classroom are similarly understudied. Planned behavior theory's attitude, subjective norms, perceived behavior control, and purpose are explored in light of their potential use in augmenting reality via the exploitation of the hedonic and instrumental values they entail in a purely two-dimensional setting. The study model and hypotheses take into account the interplay between the components. Structural equation modeling was used in conjunction with other research methods to assess the model. In the last section, I provide a more thorough explanation of the results, as well as a conclusion and a deeper analysis of the data.

2. Literature review

2. 1 Augmented reality

The educational landscape is becoming more varied in today's period of rapid technological advancement. The unique technologies that are easily accessible and used inside the e-learning system serve as an exploratory cognitive tool, facilitating communication and interaction between students and instructors [18, 19]. Moreover, smart device-based visualization, such as that seen on smartphones, tablets, and PCs, would be very useful in a variety of settings. It would be an intelligent use of technology that might help us get beyond the constraints of current learning methods. Similarly, a number of research looked at how using AR apps can affect students' motivation to study [20, 21, 22 and 23]. They detail how, in comparison to more conventional teaching methods, students in all subjects may benefit from using augmented reality applications. They said a number of pupils lacked the necessary background knowledge to successfully complete standard online coursework. Therefore, students and instructors may forge a deeper connection via the use of augmented reality to create 3D objects in online classrooms. They claimed that in the actual world, augmented reality could show all the features of a virtual display. The use of interactive technology like augmented reality in the classroom empowers students by giving them access to the most comprehensive answers to their inquiries. Students may join the virtual world, engage actively, and interact with virtual items in the actual world by using augmented reality applications, which help them develop their spatial skills.

2.2 Augmented reality's potential pleasures

The hedonic value of augmented reality is the experience of having virtual items with real-world properties. In terms of pleasure, it provides its users with an instantaneous environment that encourages merriment and experimentation [24]. The hedonic value of augmented reality is the most crucial factor because it significantly activates the users' logical and emotional approaches, causing them to interact with the virtual items in real time. Just as [25] pointed out, students' logical and emotional learning experiences have a substantial impact on their purpose to utilize augmented reality-based learning. Real knowledge and the incentive to acquire it are animated by hedonic values, such as characteristics that significantly impact the students' investment in the course [26]. The hedonic value defines the users' perceived behavioural control, which in turn affects attitude and intention. It improves the course's value and optimizes students' understanding of the factors that influence their degree of course selection. Such procedures have been investigated in relation to augmented reality. The latest development trend in augmented reality-based apps provides a novel way of seeing the world [23]. It's energizing, it lets you be yourself, it’s fun, and it gives you hedonic pleasures. As a result of augmented reality's hedonic value, students are more likely to engage in and benefit from online education [27,28].

2.3 Augmented reality's practical applications

The pragmatic benefit of augmented reality is found in the object's logical and functional message, which has a

substantial impact on the users' behavioral intention. It serves as a leading indication of progress in the development of new or current e-learning platforms [29, 30]. Results showed that students' perceptions of e-learning and their willingness to engage in such affected by AR's visibility and simulation [31]. The practical benefits of augmented reality improve the visual presentation of a virtual-based course, which in turn encourages and excites students to participate in online education [17]. In a real-world context, the utility of virtual things raises awareness, which in turn increases a positive attitude and the perceived behavioral intention to use, which in turn strengthens the beliefs. As a result of the worldwide spread of the COVID-19 epidemic, schools all around the globe were forced to cancel all in-person classes and instead rely only on online instruction. Students' realistic expectations of the course are affected by the utilitarian value approach. As a result, it affects the students' logical understanding of the online education system. Several writers have discussed hedonic and utilitarian values in relation to augmented reality, but in a different context, to investigate the impact they have on users' propensity to engage in certain actions [26]. So, this study contends that there hasn't been enough effort in the field of e-learning research to examine the impact of augmented reality on students' behavioral intention toward e-learning practices during the COVID-19 epidemic. Specifically, these theories are offered.

H1: Students' perceptions of e-learning improved when exposed to augmented reality.

H2: Student perceptions of e-learning were more favorable when using augmented reality.

H3: Students' feelings of behavioral agency in relation to e-learning improved when augmented reality was used.

The Predictive Processing Model

An individual's behavior intentions are a function of three determinants: "an individual's attitude toward behavior," "subjective standards," and "perceived behavioural control," according to the Theory of Planned Behavior (TPB) presented. Attitude describing an Individual's negative or good sentiments when performing actions [32]. One's own personal tastes determine whether one's intentions are malicious or charitable [33]. Prior research has focused on how students' attitudes regarding e-learning systems serve as a primary aspect of TPB. For instance, [34] looked at the impact of students' optimistic attitudes on their plans to engage in online education. Therefore, students' attitudes regarding e-learning using augmented reality applications are unknown and technologically-based e-learning has a significant impact on students' intentions to become actively engaged in the coursework. Individuals' perceptions of appropriate behavior are shaped by the opinions of others around them (in the context of family, friends, or peers) according to the concept of "subjective norm". Shreds of evidence from empirical investigations demonstrate subjective norms substantially influence the students' intention towards e-learning. In addition, the subjective norms of students' peers have a significant impact on their attitude toward the virtual learning system [35]. A dearth of research, however, has examined how COVID-19's subjective standards may have affected augmented reality-based e-learning systems. The concept of perceived behavior control centers on how one's visual perception influences their actions. Previous research has focused on students' behavioral intentions, as this is the point at which they experience the greatest success (or failure) with their e-learning or online-course participation. Published research have confirmed the favorable association between perceived behaviour control and technological-based e-learning [36]. Despite the urgency of the current COVID-19 pandemic, there has been a dearth of research using TPB to examine students' attitudes regarding augmented reality-based e-learning or online courses. However, many writers have adapted TPB to a wide range of fields, including healthcare, marketing, technology, consumer behavior, etc., and have defined the observable behavior of people in regards to the adoption of new or old systems [33]. [32] Claimed that this model lets the author find distinct beliefs for conduct from a specific setting and demographic. Thus, the following assumptions are formed.

H4: The disposition of students predicted their future e-learning behavior favorably.

H5: There was a favorable correlation between students' subjective norms and their desire to engage in e-learning.

H6: Students' attitudes to their own behavioral control were positively associated with their purpose to engage in online learning.

Attitude, subjective norms, and perceived behavioral control all play a mediating effect.

Low adoption by users means that the potential benefits of e-learning as an aid to remote learning and teaching may not be properly studied. This is because the deployment of new technology in e-learning would be difficult for new users. User intent is shaped by an "external" construct, according to [32], and this effect must be mediated by means of TPB structures (attitude, subjective norms, and perceived behavioural control). In a similar vein, TPB constructs' belief-based effects on contributing variables on intention are mediated by TPB constructs [32]. (Lew et al., 2019) examined the direct and mediated influence of the external variable on e-learning via the three TPB dimensions of attitude, subjective norms, and perceived behavioural control. In their studies, they found that the relationship between personality traits and future behavior intentions was partly mediated by TPB. They also found that the TPB was

responsible for mediating the connection between conscientiousness and purpose as a whole. According to research [37], TPB dimensions significantly impact the relationship between socioeconomic status and behavior. According to the research [38], TPB dimensions positively influenced the connection between extraneous variables and behavior. In contrast, research on the role of TPB constructs as mediators between interactive technology and e-learning practices is sparse. Accordingly, we hypothesized that TPB dimensions could have a moderating effect in the relationship between AR and e-learning intentions in Asia.

H7: The effect of students' outlook on augmented reality on their desire to engage in e-learning is moderated by this variable.

H8: The desire of students to engage in e-learning is related to their exposure to augmented reality, but this link is mediated by students' subjective norms.

H9: The effect of augmented reality on students' desire to engage in e-learning is moderated by their sense of behavioral agency.

2.4 Study framework

The conceptual framework (Figure 1) for this investigation was created using the existing body of knowledge on the COVID-19 pandemic and the function of augmented reality apps in distance education in mind. This research used TPB to investigate the impact that augmented reality applications have on the attitudes of Asian college students regarding e-learning. Also, in this setup, AR has an immediate impact on the TPB dimensions of Hypotheses 1, 2, and 3. As a result, Hypotheses 4, 5, and 6 (H4, H5, and H6) propose a causal link between TPB components and the desire to engage in e-learning. The TPB dimensions H7, H8, and H9 have a mediating influence on the relationship between augmented reality and e-learning intent.

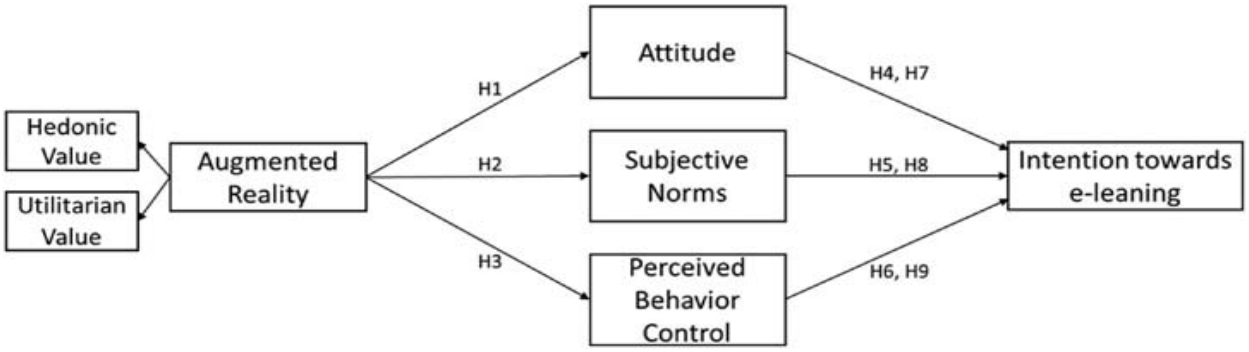

Fig. 1: AR software as a model for distance education.

3. Methodology

3.1 Data collection

One hundred thirty-five students attending a public university in the Sindh province, Asia, were selected at random for this study. Using the parameters four predictors, an effect size of 0.15, power of 0.95, and two tails, the program G*Power 3.1 calculated a minimal sample size of 89. In this investigation, we used a larger sample than is usually required. Teachers reached out to students using a WhatsApp group they set up in order to keep them informed about class and homework assignments. In order to recruit volunteers for the research, an online survey was sent throughout the groups. They were also told to download the Google Expeditions software on their phones to take use of virtual and augmented reality in their studies. In order to ensure that participants had a positive Google Expeditions experience, we asked them to answer questions that were directly connected to it. Information on the population and other descriptive data are included in Tables 1 and 2.

3.2 Data analysis

This investigation used structural equation modeling to examine the hypotheses in play (SEM). The SEM includes metrics for evaluating the study's model and for estimating the route of structural coefficients. Because of its simplicity and reliability in evaluating a model's fit to the data, this statistical modeling method is often used in studies in the social sciences and management sciences. As a result, Smart PLS software has been used to implement both a covariance-based (CB-SEM) and a partial least-squares (PLS-SEM) strategy for structural equation modeling. PLS-SEM was used for the current investigation due to its superior ability to reveal the intricate interplay between constructs

(both direct and indirect), defend theoretical frameworks, and provide a comparative display of path coefficients. The PLS approach offers a model estimate by using two models (an inner measurement model and an outer structural model) to track the connection between latent variables.

Table 1: Statistics on the population

Indicators		**Frequency**	**Percent**
Gender	Male	85	66
	Female	48	34
Age range (years)	17 – 26	106	77
	27- 35	27	23
Programme enrolled	Undergraduate	19	82
	Graduate	26	18

Table 2: Description Statistics (n=135).

	Mean	**Std. Deviation**
Augmented Reality	3.5163	1.09480
Utilitarian value	3.4561	1.15213
Hedonic value	3.5764	1.08489
Attitude	3.3434	1.14954
Subjective norms	3.8020	.98733
Perceived behaviour control	3.6742	.96963
intention towards e-learning	3.5138	1.06562

3.3 Measurement model

The theory of planned behavior was applied in this study, namely its four components: attitude, subjective norms, perceived behavior control, and goal with respect to e-learning. The use of augmented reality is a new factor to think about when assessing the effectiveness of TPB buildings. The relevant measuring tools for each structure were obtained from previous studies. Augmented reality products that are both fun and useful. Attitudes toward and distaste for e-learning, as well as social norms, perceived behavioral control, and motivation to learn, are all TPB constructs that have been measured. An identical five-point Likert scale was used to evaluate each item (5- extremely likely to 1-extremely unlikely). Convergent validity was calculated by calculating each item's Cronbach's Alpha, composite reliability, and average variance recovered. With a utilitarian loading of 0.981 and a hedonic loading of 0.980, the augmented reality construct seems to be appraised at a higher-order level. All impact sizes are more than 0.5, with values ranging from 0.636 to 0.819 on average. Cronbach's alpha coefficients () and reliability coefficients (CR) for all constructs are above the cutoff of 0.6. The AVE is considered discriminantly valid when its square root is bigger than the correlation. Tables 3 and 4 provide summaries of the results of the various measures.

3.4 Structural model

In this work, the hypothesized connection between all components was analyzed using PLS-SEM. The data was analyzed using Smart PLS (v3.2.9). The direct and indirect connections were calculated using a bootstrapping approach with 5500 subsamples and a t-statistic. The majority of the structural model's description was taken up by path coefficients and R2 values (Figure 2 and Table 5).

3.5 Hypothesis testing

Values showing the strength of the association, the amount of variation explained by the model (R2), and the degree of significance that may be retrieved from a SmartPLS study. To investigate the interdependencies between the variables, a bootstrapping study including 5500 replicates was conducted. Effects of Augmented Reality, Attitude, Subjective Norms, and Perceived Behavior Control on E-Learning Intentions are shown in Tables 5-7. (INT). Attitude (R2 = 0.698), subjective norms (R2 = 0.532), and perceived behavioral control (R2 = 0.522) were all partially explained by AR. Together, the TPB dimensions and augmented reality explained 67.2% of the variation in e-learning intent. For hypotheses 1 through 4 and 6, the direct correlation is quite significant. Conclusion H5: findings are inconclusive. In the case of indirect relationships, H7 and H9 both point to a complete mediation effect. However, subjective norms do not play a mediating role in the relationship between AR and e-learning intent. One significant outcome is the overall indirect influence that AR has on people's desire to engage in e-learning.

Table 3: Complete concept validity and reliability.

Measurement Items	**Loadings**	**α**	**CR**	**AVE**
Augmented Reality AR: Utilitarian Value	0.981	0.885	0.913	0.636
UVL1. Using this augmented reality app improves my performance in	0.772			

evaluating the coursework during e-learning. UVL2. I find this augmented reality app to be useful for e-learning.	0.799			
UVL3. Using this augmented reality app enhances my effectiveness in e-learning.	0.856			
AR: Hedonic Value	0.980			
HVL1. The e-learning experience with this augmented reality app makes me feel good.	0.828			
HVL2. The e-learning experience with this augmented reality app is exciting.	0.835			
HVL3. The e-learning experience with this augmented reality app is enjoyable. *Attitude*	0.795	0.767	0.866	0.683
ATU1. I would like my e-learning more if I used this augmented reality app.	0.785			
ATU2. Using this augmented reality app in my e-learning would be a pleasant experience.	0.875			
ATU3. Using this augmented reality app in my e-learning is a wise idea. *Subjective Norm*	0.817	0.762	0.863	0.679
SN1: Most people who are important to me think it would be sufficient to use this augmented reality app for e-learning. SN2: I think other students in my classes would be willing to adapt this augmented reality	0.832 0.890			
app for e-learning. SN3: Most people who are important to me would favour using this augmented reality app	0.743			
for e-learning. *Perceived Behavioural Control*		0.702	0.680	0.819
BC1: I have a sufficient extent of knowledge to use this augmented reality app for e- learning. BC2: I have a sufficient extent of control to adopt this augmented reality app for e-learning.	0.798 0.741			
BC3: I have sufficient self-confidence to decide to adopt this augmented reality app for e- learning.	0.787			
Intention Towards e-Learning INT1: I predict I would use augmented reality apps for my e-learning.	0.813	0.716	0.841	0.638
INT2: I plan to use augmented reality apps for e-learning in the future.	0.751			
INT3: I intend to adopt augmented reality apps for e-learning.	0.831			
Note: α: Cronbach Alpha, CR: Composite Reliability, AVE: Average Variance Extracted.				

4. Discussion

The purpose of this research was to use the idea of planned behavior to explore the use of augmented reality in e-learning strategies during the COVID-19 epidemic in Asia. The results of this research showed that college students' attitudes and sense of behavioral control had an effect on their intent to use an augmented reality app for online education. Although students' intentions toward e-learning were affected, this effect was not statistically significant when controlling for subjective standards. Reason should be applied to the use of augmented reality applications in online education. By presenting virtual items in 3D, 4D, and even 5D in a real-world setting through smartphones and tablets, augmented reality applications enrich students' learning experiences. It seems to reason that an augmented reality software would foster more participation and, thus, greater learning. As a result of the COVID-19 epidemic, schools urgently need to reconsider their approach to online learning. Garzón and Acevedo (2019) were among the first to highlight the benefits of an online course as a means of streamlining the teaching process. It is suggested that augmented reality applications enable students to participate in the coursework via the presentation of various 3D graphics, videos, or voice notes. Furthermore, pupils would have more faith in learning using augmented reality applications because of their novelty compared to traditional online lectures. There is some doubt as to whether or not the subjective normative value of college students will change as a result of the widespread use of augmented reality in online learning. Since the announcement of the COVID-19 pandemic, [38] note that most educational institutions are still employing outdated technologies like Zoom and Google Class to provide online courses, which are likely failing to attract a large proportion of their target audience. Most of the individuals who matter to students have little interest in adopting an augmented reality app for online education. The causes of this occurrence need to be determined, and additional qualitative research is required to do so. University students' knowledge and psychological resistance to e-

learning are both improved by meaningful learning experiences. Since the worldwide announcement of the COVID-19 pandemic, many online educational platforms have been made available. According to [40], AR applications may help students engage with the fundamental concepts of their studies while also providing them with virtual assistance in completing practical assignments. The presence of virtual items in the actual environment is augmented by reality's defining characteristic, which affects users' physiological responses to the information being presented.

Table 4: Value for Discrimination.

	1	2	3	4	5
1. Attitude	0.847				
2. Augmented reality	0.835	0.980			
3. Intention towards e-learning	0.793	0.723	0.799		
4. Perceived behavioural control	0.735	0.723	0.723	0.776	
5. Subjective norms	0.491	0.729	0.462	0.541	0.824

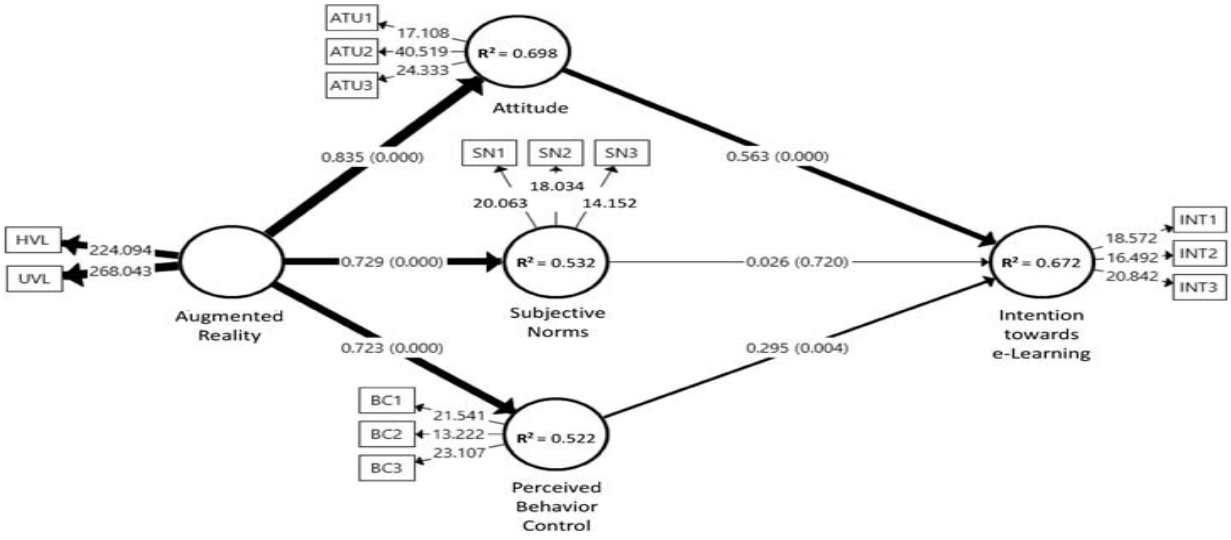

Fig. 2: Utilizing an App-Based Augmented Reality Structural Equation Model for Distance Learning.

Table 5: The Path to Coefficients and Outcomes.

Paths	β values	*t* values	Hypothesis results
AR → ATU	0.835***	29.439	H1 - yes
AR → SN	0.729***	17.402	H2 - yes
AR → BC	0.723***	17.88	H3 - yes
ATU → INT	0.563***	5.866	H4 - yes
SN → INT	0.026	0.358	H5 – no
BC → INT	0.295*	2.862	H6 – yes

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 6: Directly indirect consequences.

Paths	□value	P values	Lower Threshold	Upper Threshold	Hypothesis	Mediation Type
AR → ATU → INT	0.471	0.000	0.29	0.626	H7	Indirect-only (full mediation)
AR → SN → INT	0.019	0.724	−0.088	0.12	H8	No effect (no mediation)
AR → BC → INT	0.213	0.006	0.079	0.377	H9	Indirect-only (full mediation)

Table 7: Overall indirect impact

Path	β values	*t* values	*p* values
AR → INT	0.703	16.609	0.000

5. Conclusion

In this research, we look at college freshmen's desire to use an augmented reality app for distance education. The results of the survey showed that college students want to make extensive use of augmented reality apps for online education. Lectures delivered using augmented reality software have been shown to improve students' attitudes, subjective norms,

and perceptions of their own behavioral agency. However, students have a hard time logging on to online courses using more conventional means, such as online video lectures, because of the ongoing COVID-19 epidemic [41]. Higher education institutions and students in both developed and developing nations continue to face cultural barriers and technological complexities related to e-learning. The participants in this research can only be undergraduates from public Asian institutions [42]. This limits the study's applicability to schools and students of varying levels of education. As a result, qualitative and quantitative studies, or a combination of the two, provide promising new directions for investigating the potential benefits and drawbacks of using an AR software to spread knowledge to students of all ages and backgrounds in a variety of settings [43].

Conflict of interest

The authors declare that there is no conflict regarding the publication of this paper.

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