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From physical to virtual: The impact of mixed reality technologies on students' engagement in Kuwait universities using structural equation modeling

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A B S T R A C T

This paper sought to test the impact of mixed reality technologies on student engagement in Kuwait universities. Physical reality, augmented reality, augmented virtuality, and virtual reality have been relied upon as mixed reality technologies. Moreover, behavioural, cognitive, and emotional engagement were used as measures of students' engagement according to self-determination theory. The data used in the analysis were received from 812 students in various disciplines in Kuwaiti universities with a response rate of 86.19%. Structural equation modeling (SEM) was the statistical approach used in data analysis. The results indicated varying relative importance levels for mixed reality techniques, although the relative importance level for students' engagement was high. Besides, all mixed reality technologies had a positive impact on students' engagement, with the highest impact of augmented reality and the lowest impact of augmented virtuality. This paper provided contributions to the development of an empirical approach based on new technologies to improve student engagement in developing country universities. Accordingly, the paper emphasized the need for Kuwaiti universities to invest in augmented reality technologies, for example, interactive screens and 3D mobile applications to increase students' exploratory ability.

1. Introduction

Most students were affected by the closure of the educational system during Covid-19. Reports mentioned that approximately 72% of university students around the world postponed their semesters to avoid participating in distance education (Xu & Xu, 2019; Zhang et al., 2022). The studies attributed the prevailing lack of acceptance of distance education as a result of the novelty of the method (Salta et al., 2022), along with the inability to identify the required online skills for knowledge acquisition, especially in experimental scientific disciplines (Zarei & Mohammadi, 2022). However, the students faced a new pattern in the educational method after the end of the closure phase. This pattern is based on intensifying reliance on mixed reality technologies instead of focusing on traditional technologies only (Pickering et al., 2022; Akour et al., 2023). Mixed reality results from the thoughtful combination of face-to-face education and distance learning experiences (Al-Shormana et al., 2021; Tang et al., 2020). This approach permits the investment of modern technologies to support educational materials and provides greater opportunities for students to conduct experiments and analyze results through a virtual reality emanating from the conditions of the physical environment (Dalinger et al., 2020). Indeed, the success of the educational system, whether it is face-to-face or digital, is based on building strong engagement and interaction of students within the educational environment (Alyahyan & Düştegör, 2020). However, the motivating factors are quite different between the two environments. The physical educational environment depends on, for example, tangible stimuli and visual human feelings, while interaction in the virtual environment is based on flattery messages and intangible digital icons (Cheng, 2021). Moreover, student

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engagement continuity has emerged as a challenge in the contemporary educational system, as self-determination theory explains that human engagement depends on the psychological needs of autonomy, competence, and relationship that drive them to continue or not (Mohammad et al., 2022; Chiu, 2021). However, Fredricks et al. (2019) explained that some contextual factors such as teacher ability and peer behaviour can enhance student engagement in new modes of education by triggering reward-related challenges.

The role of online and distance education in stimulating the engagement of pre-university students has been discussed extensively in previous literature (Harahap et al., 2022; Chen et al., 2021; Muda et al., 2022; Baloran & Hernan, 2021; Harris et al., 2022). On the other hand, the implications of applying mixed reality technologies in higher education have been ignored, although their recent spread in various university disciplines. Moreover, the apparent prevalence of such studies was in the education systems of developed countries, where it was noted that there were few studies that examined the role of such emerging technologies in enhancing student engagement in the educational environment. Therefore, the current research raised a question about the impact of mixed reality technologies on the engagement of Kuwaiti university students. The Kuwaiti Ministry of Higher Education has recently adopted an approach that enables increased government spending on university facilities to purchase digital supplies and equipment that enable the development of a contemporary educational environment. Accordingly, this research could clarify the relationship between mixed reality technologies for enhancing the engagement of university students in a virtual learning environment, thus improving the investment of state financial resources.

2. Literature Review and Hypotheses

2.1 Mixed reality technologies

Mixed reality technologies may be the most effective and functional of the new educational technologies, as they use resources extending from the physical environment to the virtual environment (Tang et al., 2020). Software that supports the mixed reality approach has spread, but Microsoft was the first to develop the path through the HoloLens headset that allows the user to control it based on verbal commands and hand gestures (Verhey et al., 2020). Mixed reality in education was defined as a hybrid environment that integrates interactive objects designed in a virtual environment into the physical environment (De Belen et al., 2019). Rokhsaritalemi et al. (2020) determined three characteristics of mixed reality technologies: (i) real-time interaction with commands, (ii) 3D linking within digital content, and (iii) containing real domain supported by virtual objects. In another context, Kaplan et al (2021) expressed the mixed reality approach as tools for collecting data from the physical and virtual environment to perform interactive integration between humans and machines through head equipment, voice sensors, and gestural reception.

The development of display technologies and their lower costs compared to the past period contributed to their widespread use in educational fields such as architecture, operations management, and medicine (AL-Zyadat et al., 2022; Mohammad, 2019; Rahamneh et al., 2023; Attiany et al., 2023; Al-Rwaidan et al., 2023; Zahran et al., 2023). The mixed reality approach includes four main areas: physical reality, augmented reality, augmented virtuality, and virtual reality. Physical reality expresses the real environment with its tangible components and the user's ability to interact directly with it through the five human senses (Nguyen et al., 2021). Physical reality represents the basic structure for building an interactive mixed reality that makes it easier for the user to understand the changes resulting from adding virtual elements (Zheng & Sun, 2023). Augmented reality (AR) is associated with interactive displays through screens that support special sound and motion effects generated by computers to enhance the user experience in real reality (Yang et al., 2023). AR provides an enhanced view of physical reality by adding depth to the abstract image in a way that allows the user to enhance the visual field (Jumani et al., 2022). In contrast, augmented virtuality (AV) relates to physical objects inserted into a virtual environment of various levels of complexity (Howard & Davis, 2022). AV uses custom sensors to monitor elements of the physical environment and create models that can be easily manipulated in the virtual environment (Wolf et al., 2022). Moreover, the AV approach is one of the latest technologies that need extensive study as a result of the development of the use of virtual reality and related software (Vellingiri et al., 2023). Virtual reality (VR) is the total immersion in an unreal computer-generated environment supported by sound and kinesthetic stimuli (Parmaxi, 2023). VR provides the user with the possibility of an immersive experience of processes and aspects that are difficult to achieve in the physical environment through layers that can be controlled interactively (Choi et al., 2022). Besides, this approach allows partial or complete simulation of a series of codes to accomplish a specific project or process and detect deviations to address them before executing them in the real environment (Fussell& Truong, 2022).

2.2 Students' engagement

The concept of student engagement falls within the field of special and differential treatment (SDT), as it is considered the result of the motivational process that in turn gives the student energy and activity to participate in educational activities (Bowden et al., 2021; Al-Hawary et al., 2022). In this context, the SDT could determine the critical and extrinsic factors of motivation, therefore, it suggests that the prevailing social and cultural context contributes to limiting an individual's well-being and performance outcomes (Wood, 2020). Accordingly, Chiu (2021) defined student engagement as the student's active participation and adherence to educational goals in order to improve academic achievement and the results of the educational process. Sun et al. (2019) stated that student engagement is an expression of the degree of interest and curiosity associated with acquiring new knowledge and commitment to achieving positive results. The student's engagement is positively related to the level of satisfaction and the degree of support, as these factors move the student's motivation to a higher level associated with intrinsic motivation based on fulfilling autonomy, competence, and relationship needs (Mohammad, 2020; Benlahcene et al., 2021).

Student engagement is a complex construct consisting of three dimensions: (i) behavioral engagement, (ii) cognitive engagement, and (iii) affective engagement. Behavioral engagement refers to students' implementation of learning activities both inside and outside the educational environment (Chiu, 2021). Students who have behavioral engagement show higher levels of taking responsibility for their learning and pursuing development (Baloran& Hernan, 2021; Mukhlis et al., 2022; Boudlaie et al., 2022). Cognitive engagement expresses the mental effort to accomplish tasks using a self-organized and strategic approach to information extraction (Wood, 2020). Moreover, It focuses on defining the purpose of educational activities and exploring tasks that result in new knowledge (Ferrer et al., 2020). Accordingly, students with a high level of cognitive engagement tend to actively participate in proactive activities to obtain the greatest amount of information produced in the educational process (Núñez& León, 2019). On the other hand, affective engagement represents students' emotional reactions and response towards peers and teachers (Sun et al., 2019). This dimension revolves around the feelings of happiness, anxiety, and boredom that the student shows towards the educational environment. Affective engaged students tend to act freely and safely as a result of feeling at home. Harris et al. (2022) explained that despite the interdependence between the three dimensions of student engagement, they are intertwined and used to stimulate sustainable motivation among students towards the integrated educational system.

2.3 Mixed reality technologies and students' engagement

Improving the cognitive achievement of university students is linked to the availability of a stimulating educational system that supports modern education paths. Recent technical developments and the expansion of the use of the Internet in education have produced a wide range of educational technologies that universities must adapt to. Mixed reality technologies represent the latest developments related to the educational process, as they enable students to conduct real-world experiments using interactive technologies visually, auditory, and kinesthetically. Accordingly, Chiu (2021) examined the effect of digital support for blended learning on the engagement of eleventh-grade students. His findings confirm that digital support has a positive impact on students' engagement through multiple methods of delivering information and emotional designs. Tang et al. (2020) conducted a study to determine the difference in student effectiveness between physical education approaches and mixed education approaches. The study concluded that the use of the mixed approach led to an improvement in the analytical ability of the students, as well as produced a clear change in the educational behavior of the students through motivation based on entertainment. Baloran and Hernan (2021) carried out a study to explore the relationship between course satisfaction and student engagement in the Philippines during the COVID-19 pandemic. The results demonstrated different levels of engagement among students as a result of applying the online education method. Moreover, the results confirmed the positive effect of satisfaction on the level of students' engagement in online education. Choi et al. (2022) analyzed the literature on the advantages and barriers to using virtual reality in nursing education. Using a structured approach based on the cumulative index of nursing and allied health literature, the study concluded that virtual reality improved students' cognitive and psychomotor performance. Otherwise, the lack of technological infrastructure such as simulation tools limited its use in education. In a systematic review of 259 research papers published during the years 2013-2018 related to mixed reality technologies, it was found that these technologies affected many disciplines by improving annotations based on non-verbal gestures and complex three-dimensional patterns (De Belen et al., 2019). Accordingly, the following research hypotheses were proposed to test the impact of mixed reality technologies on student engagement:

H_{1a}: *Physical reality has a positive impact on students' engagement.*

H_{1b}: *Augmented reality has a positive impact on students' engagement.*

H_{1c}: *Augmented virtuality has a positive impact on students' engagement.*

H_{1d}: *Virtual reality has a positive impact on students' engagement.*

According to the research hypotheses, the proposed conceptual research model shown in Fig. 1 could be designed.

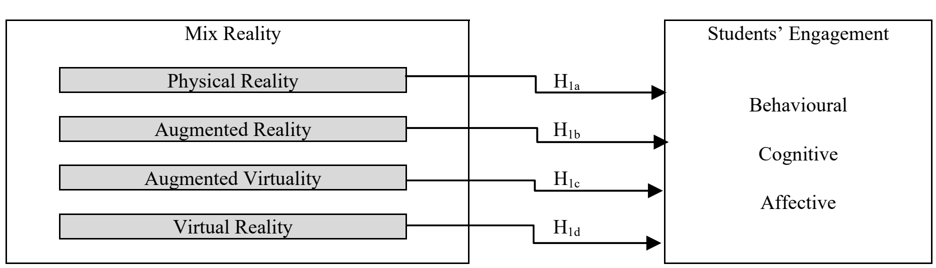

Fig. 1. Proposed model

3. Methodology

3.1 Participants

The research relied on primary data collected from a population of Kuwaiti university students. The educational system constitutes the cornerstone for providing the rest of the industrial sectors with qualified and high-quality human resources to achieve progress development (Alenezi & Brinthaupt, 2022). Kuwait has a higher education system consisting of 25 universities that provide annual educational opportunities for approximately 8000 students in various disciplines. Therefore, the application of the comprehensive survey approach in collecting research data was inefficient due to financial and temporal constraints. Hence, the research data was collected through a convenience sampling approach with a minimum number of valid responses from 385 students (Wettzman, 2022). The responses received were 942 responses that included 130 responses that did not meet the requirements of statistical analysis. After excluding those responses, the final research sample consisted of 812 respondents representing 86.19% as a valid response of the total received. Bloomfield and Fisher (2019) mentioned that valid responses which exceed 60% are considered evidence of the adequacy of the research sample. In a demographic analysis of the research participants' components using frequencies and percentages, the results indicated that most of them 64.6% were males compared to 35.4% were females. 56.1% of the respondents were Kuwaiti citizens, followed by 34.2% nationalities of Gulf states, and then only 9.7% of the rest of the Arab nationalities. Moreover, the results showed that 53.2% were affiliated with scientific faculties while 46.8% were affiliated with literary and humanities faculties. On the other hand, most of the respondents were studying at the bachelor's level 59%, followed by diploma students 27.1%, and then postgraduate students 13.9%.

3.2 Data collection and measures

A self-reported questionnaire was used to collect the primary data associated with the research variables. This questionnaire was designed electronically through Google forms after obtaining the approval of the Kuwaiti Ministry of Higher Education. To achieve high response rates, the questionnaire link was published on students' social media platforms and the official websites of Kuwaiti universities. Furthermore, responses were received within the period from February 5, 2023, to March 9, 2023. The questionnaire included three sections, the first one represented a cover letter explaining the purpose of the research, together with an emphasis on research ethics commitment and data confidentiality. The second section included demographic data. The third section, whose responses were determined by the five-point Likert scale, included the items of the main research variables:

Mixed reality technologies: The exogenous variable, which was defined procedurally as the Kuwaiti universities' investment in technological development to transfer towards distance education and self-learning. 16 items were used to measure the mixed reality technologies developed according toTang et al. (2020). These items were branched into four first-order constructs. Physical reality was measured by three items “e.g., physical reality enhances cognitive abilities through intense communication and human reactions”. Augmented reality was measured by five items “e.g., lectures are provided with QR codes to enable access to interactive 3D models related to the topic of discussion”. Augmented virtuality was measured by four items "e.g., the university laboratories include virtual elements that could be inserted into the physical environment through a mobile phone to conduct practical experiments". Virtual reality was measured by four items “e.g., universities provide their student laboratories with simulators, which are used to train students to deal with different scenarios”.

Students' engagement: The endogenous variable, which was defined procedurally as the ability of Kuwaiti universities to stimulate the cognitive ability of students and direct them behaviorally and emotionally to participate in the process of knowledge acquisition and dissemination. 13 items were used to measure the students' engagement borrowed from Topu and Goktas (2019). These items were branched into three first-order constructs. Behavioural engagement was measured by five items “e.g., I volunteer to participate in the educational activities that take place during the lecture”. Cognitive engagement was measured by four items “e.g., I try to formulate the learned knowledge in my own language and link it to the course of life”. Affective engagement was measured by four items “e.g., I am interested and enjoy participating in the lecturer's discussions with the students”.

4. Findings

4.1 Measurement model assessment

The measurement model was evaluated for its validity and reliability. This procedure helps to enhance the ability of the researcher to achieve accurate results that could be generalized (Hair et al., 2020; Saraireh et al., 2022). Validity was measured by indices of convergent validity and discriminant validity. Furthermore, reliability was evaluated through internal consistency and composite reliability. Table 1 lists the results of assessing the measurement model for mixed reality technologies impact on students' engagement. The results of Table 1 indicated that factor loadings were within the range of (0.664-0.818). The average variance extracted (AVE) values were greater than the lower threshold of 0.50 (Dos Santos, 2022; Mohammad et al., 2020). Lekwa et al. (2019) stated that factor loadings greater than 0.50, together with AVE values that exceed the lower threshold are evidence of the convergent validity of the measurement model. Thus, the measurement model for testing the impact of mixed reality technologies on student engagement had convergent validity. On the other hand, the discriminant validity was evaluated through Fornell and Larcker criteria. This method is based on comparing the square root values of

AVE and the correlation coefficients between the latent constructs. The results confirmed that all square root values for AVE were higher than the correlation coefficients, thus that discriminate validity had been achieved (Rasoolimanesh, 2022). This result was supported by the maximum shared variance (MSV) values which were lower than AVE (Roemer et al., 2021).

Table 1
Convergent validity, discriminant validity, and reliability

Constructs	Factors	Loadings	AVE	MSV	√AVE	α	ω
Physical reality	PR1	0.781	0.613	0.454	0.783	0.824	0.826
	PR2	0.802					
	PR3	0.766					
Augmented reality	AR1	0.711	0.518	0.312	0.720	0.840	0.843
	AR2	0.664					
	AR3	0.764					
	AR4	0.735					
	AR5	0.720					
Augmented virtuality	AV1	0.739	0.515	0.365	0.717	0.808	0.809
	AV2	0.681					
	AV3	0.706					
	AV4	0.742					
Virtual reality	VR1	0.767	0.636	0.475	0.798	0.872	0.875
	VR2	0.812					
	VR3	0.793					
	VR4	0.818					
Behavioural engagement	BE1	0.716	0.543	0.439	0.737	0.855	0.856
	BE2	0.702					
	BE3	0.746					
	BE4	0.766					
	BE5	0.751					
Cognitive engagement	CE1	0.692	0.535	0.375	0.731	0.819	0.821
	CE2	0.734					
	CE3	0.728					
	CE4	0.769					
Affective engagement	AE1	0.756	0.551	0.392	0.742	0.830	0.831
	AE2	0.718					
	AE3	0.762					
	AE4	0.733					

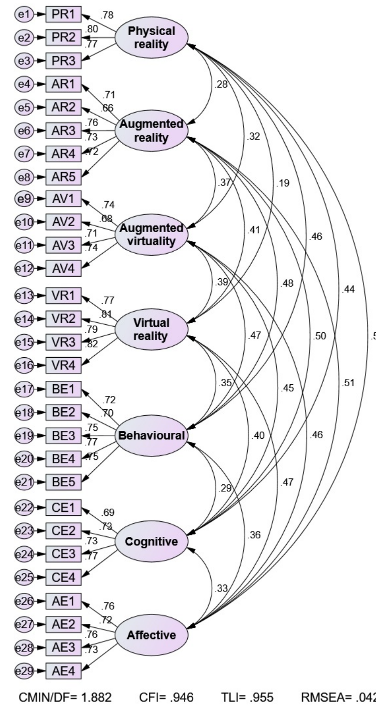

Fig. 2. Result of confirmatory factor analysis

Furthermore, the Cronbach alpha coefficients used to determine internal consistency were within the domain (0.808-0.872). Similarly, the McDonald's Omega coefficients, which measured composite reliability, were within the range of its lower limit of 0.809 and upper limit of 0.875. Based on Hayes and Coutts (2020), the composite reliability and internal consistency of the measurement model are achieved when coefficient values exceed a threshold of 0.70. Accordingly, the measurement model of the impact of mixed reality technologies on student engagement had an appropriate level of reliability. Besides, confirmatory factor analysis (CFA) was used to extract the goodness of fit indicators that evaluate the constructional validity of the proposed model, which is illustrated in Fig. 2. The results of Fig. 2 show that the chi-square coefficient to degrees of freedom was 1.882, which means that it is lower than the upper threshold 3 (Ma et al., 2021). The comparative fit index (CFI) and the Tucker–Lewis index (TLI) were 0.946 and 0.955 respectively, thus they were greater than the lower limit of 0.90 (Shi et al., 2019). Moreover, the root mean square error of approximation (RMSEA) was 0.042, which did not reach the higher acceptable level of 0.08 (Gao et al., 2020). Based on these results, the proposed model could be considered as having constructional validity that helps define the relationship between mixed reality technologies and students' engagement.

4.2 Descriptive statistics

A set of methods were applied to extract descriptive statistics related to this research. The mean was used to assess the relative importance levels of the variables based on the respondents' perspectives. The standard deviation, as a measure of dispersion, was applied to determine the spread of responses around the general trend. As for the correlation, it was used to evaluate the relationship between the variables and to ensure that the data were free from the multicollinearity problem. Table 2 demonstrates the results of the descriptive statistics of mixed reality technologies and students' engagement.

Table 2
Mean, standard deviation, and correlation

Constructs	M	SD	PR	AR	AV	VR	BE	CE	AE
Physical reality	3.72	0.764	1						
Augmented reality	3.69	0.801	0.524	1					
Augmented virtuality	3.56	0.824	0.415	0.497	1				
Virtual reality	3.62	0.811	0.503	0.411	0.406	1			
Behavioural engagement	3.75	0.764	0.647	0.687	0.564	0.634	1		
Cognitive engagement	3.73	0.698	0.624	0.655	0.603	0.622	0.647	1	
Affective engagement	3.70	0.799	0.634	0.615	0.597	0.611	0.659	0.636	1

According to the results of Table 2, the mixed reality technologies ranged between high and moderate relative importance levels. Physical reality (M= 3.72, SD= 0.764) ranked first with a high level, followed by augmented reality (M= 3.69, SD= 0.801) ranked second with the same level. As for virtual reality (M= 3.62, SD= 0.811), it was in the third rank with a moderate level, followed by augmented virtuality (M= 3.56, SD= 0.824) in the last rank with a moderate level. Otherwise, all students' engagement variables had high relative importance levels. Behavioural engagement (M= 3.75, SD= 0.764) was in the first rank, followed by cognitive engagement (M= 3.73, SD= 0.698) in the second rank, then affective engagement (M= 3.70, SD= 0.799) in the third and last rank. Moreover, Table 2 presented the results of Pearson's correlation coefficients between variables, which were within the range of (0.564-0.687) regarding the relationship between mixed reality variables and students' engagement. In addition, the Pearson correlation coefficients between the mixed reality variables were within the domain (0.406-0.524), therefore, the research data did not contain multicollinearity since the correlation coefficients were less than 0.80 (Kim, 2019).

4.3 Structural equation modeling

To determine the impact relationship of mixed reality technologies on students' engagement, the structural equation modeling (SEM) shown in Fig. 3 was applied.

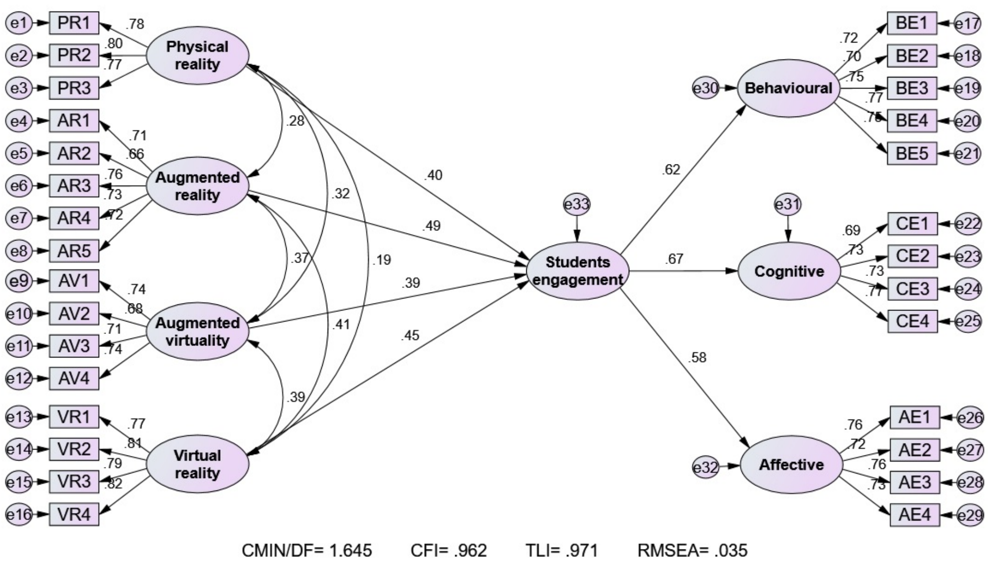

Fig. 3. SEM for the impact of mixed reality on students' engagement

The results of Fig. 3 demonstrate that the chi-square coefficient to degrees of freedom was 1.645, which means that it is lower than the upper threshold 3 (Ma et al., 2021). The comparative fit index (CFI) and the Tucker–Lewis index (TLI) were 0.962 and 0.971 respectively, thus they were greater than the lower limit of 0.90 (Shi et al., 2019). Moreover, the root mean square error of approximation (RMSEA) was 0.035, which did not reach the higher acceptable level of 0.08 (Gao et al., 2020). Based on these results, the structural model could be considered as having constructional validity. Besides, the result in Table 3 lists the path coefficient to evaluate the research hypotheses.

Table 3
Path coefficients for the impact of mixed reality on students' engagement

Path			B	S.E.	β	t	p
Physical reality	→	Students' engagement	0.461	0.041	0.403	11.24	0.008
Augmented reality	→	Students' engagement	0.534	0.038	0.487	14.05	0.000
Augmented virtuality	→	Students' engagement	0.411	0.043	0.391	9.56	0.02
Virtual reality	→	Students' engagement	0.502	0.039	0.452	12.87	0.000

The first hypothesis (H_{1a}) was arguing for the effect of physical reality on students' engagement. The results of Table 3 supported this hypothesis, as it was found that physical reality (β= 0.403, t= 11.24, p< 0.05) had a positive effect on student participation. The second hypothesis (H_{1b}) expressed the effect of augmented reality on students' engagement. This hypothesis was supported as it was found that augmented reality (β= 0.487, t= 14.05, p< 0.05) had a positive effect on students' engagement. Similarly, the third hypothesis (H_{1c}) indicated that augmented virtuality had an effect on students' engagement. The results indicated support for this hypothesis, as augmented virtuality (β= 0.391, t= 9.56, p< 0.05) had a positive effect on students' engagement. Moreover, the fourth hypothesis (H_{1d}) discusses the effect of virtual reality on students' engagement. The results proved support for this hypothesis, as virtual reality (β= 0.452, t= 12.87, p< 0.05) had a positive effect on students' engagement.

5. Discussion and Conclusions

The research sought to investigate the impact of mixed reality technologies on students' engagement in Kuwaiti universities. The statistical results showed that the level of mixed reality technologies was moderate. This result indicated the tendency of Kuwaiti universities to follow the transformation of the traditional educational system into a more advanced system supported by contemporary digital technologies. However, physical reality is still the most widely used mainstay in these universities. Dalinger et al. (2020) attributed the reason for the continuous reliance on physical reality to the need for training courses for lecturers on the use of contemporary technology, along with the requirements of some academic disciplines related to actual experience. The increasing reality has a high acceptance level among students in Kuwaiti universities, which is in line with Kaplan et al. (2021). Thus, Kuwaiti universities use interactive screens and patterns that integrate virtual elements into the physical environment to improve students' cognitive achievement. On the other hand, both augmented virtuality and virtual reality were of a moderate level. This level of application has been attributed to the difficulty in convincing lecturers to make an extra effort to shift towards virtual education. Moreover, the rapid development of these technologies has made it hard to choose what fits within the infrastructure and cultural context of Kuwaiti universities.

Student engagement in Kuwaiti universities was at a high level. The reason for this level is due to the availability of incentives in the educational system of Kuwaiti universities that encourage students to increase their participation in educational activities. Behavioural engagement was the highest level among students' engagement dimensions (Baloran& Hernan, 2021). It could be concluded that students in Kuwaiti universities follow a continuous learning approach through voluntary participation in the classroom along with the search for knowledge outside the classroom. Cognitive engagement was also at a high level (Lekwa et al., 2019). Consequently, students are interested in improving their academic achievement and increasing their ability to acquire knowledge through the strategy of cognitive exploration instead of relying only on superficial strategies in receiving information from the lecturer. Similarly, affective engagement was at a high level. Hence, the environment of Kuwaiti universities provides a climate of cultural harmony and feelings of respect and appreciation among peers and lecturers alike. This climate contributed to improving the emotional connection between students and the university environment so that they feel that they are behaving as they are at home.

The results of the research hypotheses were as expected, as the results indicated that mixed reality technologies, i.e., physical reality, augmented reality, augmented virtuality, and virtual reality, affected the students' engagement. The most significant impact was augmented reality. Thus, technologies based on the inclusion of virtual objects within the physical environment through display devices and voice interaction contribute to enhancing students' ability to acquire new information and improve their connection with the university environment. Virtual reality was second in terms of impact. Accordingly, the virtual environment based on advanced computer systems helps stimulate student behaviour to discover aspects related to the subject of study and improve exploratory motives even after completing official working hours at the university. Physical reality was ranked third in terms of impact. This result indicated that despite the application of modern technologies in the university educational system, reliance on real experience is still used to encourage students to increase their belonging to the university environment. As for augmented virtuality, it was ranked last in terms of impact. Hence, universities' investment in this technology helps slightly improve the emotional attachment of students as a result it is still in development and requires considerable financial resources to use efficiently.

6. Implications and Limitations

This research presented a variety of applied and theoretical implications based on its results. The theoretical implications revolve around the development of an empirical approach that demonstrates the role of contemporary technologies in improving the educational system in developing countries. Moreover, the results of this research supported the foundations of the theory of self-determination associated with improving the engagement of university students based on enhancing the autonomy, competence, and relationship provided by modern educational systems. In another context, applied implications emphasized the need for Kuwaiti universities to invest in augmented reality technologies, for example, interactive screens and 3D mobile applications to increase students' exploratory ability. Moreover, this research called on decision-makers in Kuwaiti universities to provide virtual reality laboratories that enable students to conduct practical experiments that enhance their emotional connection in the university environment. On the other hand, the research recommended focusing on developing educational platforms supported by mixed reality technologies to reduce students' dependence on the physical environment and motivate them to participate in distance education through educational patterns based on entertainment motives.

This research provided many theoretical and applied implications, however, it includes some limitations that should be noted for remediation in future research. First, this research was designed in the form of a cross-sectional study based on quantitative data collected from Kuwaiti university students simultaneously. Future studies could follow a longitudinal design that shows the change in results over time. Second, the research instrument was distributed to a wide sample of students from all disciplines in Kuwaiti universities. The results confirmed that the scientific disciplines were the most application of mixed reality techniques. Hence, we suggest in future studies to collect data from these faculties such as medicine and engineering to increase the accuracy of the results. Finally, this research examined the impact of mixed reality technologies on students' engagement in Kuwaiti universities. Therefore, future studies could investigate the impact of these variables in other developing countries such as Saudi Arabia and Qatar. Moreover, these studies could explore the impact of mixed reality technologies on variables that improve the educational system and increase the cognitive capabilities of students, for example, student satisfaction or student empowerment.

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