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Exploring the Potential of Mixed Reality in Enhancing Student Learning Experience and Academic Performance: An Empirical Study

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Abstract: In recent years, mixed reality (MR) technology has emerged as a promising tool in the field of education, offering immersive and interactive learning experiences for students. However, there is a need to comprehensively understand the impact of MR technology on students' academic performance. This research aims to examine the effect of mixed reality technology in the educational setting and understand its role in enhancing the student's academic performance through the student's novel learning experiences and satisfaction with the learning environment. The present research has employed a quantitative research design to undertake the research process. The survey questionnaire based upon the five-point Likert scale was used as the data collection instrument. There were 308 respondents studying at various educational institutes in Saudi Arabia, all of whom were using mixed reality as part of their educational delivery. The findings of the present research have indicated that the application of mixed reality by creating experiential learning, interactivity and enjoyment can significantly enhance the student's novel experience, which can directly enhance students' satisfaction with learning objects and the learning environment, as well as indirectly enhancing the student's academic performance. The research offers various kinds of theoretical implications and policy implications to researchers and policymakers.

Keywords: mixed reality; learning experience; satisfaction; academic performance

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1. Introduction

Education has always been conceived as being formed of physical classroom activities in which students and teachers meet face to face [1]. Educational content delivered by the teachers is then processed by the students [2]. However, in the wake of the COVID-19 pandemic other means of delivering education have become much more widespread [3], and educational institutes worldwide have shifted towards online or remote learning modes using current digital technologies [4]. The video conferencing software packages such as Zoom, Microsoft Teams, and Google Meet have become tools for educational institutes to shift their operation to online media [5]. Although video conferencing software provided an immediate solution for educational institutions to continue their operations [6], various problems have been reported [7]. One of the critical problems which has been widely reported in the academic literature is related to students' fatigue, lack of interactivity and motivation, and negative students' academic performance [8]. It is argued that students educated during the pandemic will suffer huge academic losses due to participating in online classes, as such classes do not provide learning experiences using sensory organs equivalent to physical classes [9]. Thus, online classes using current digital technologies have led to students developing fatigue and falling behind in their learning [10]. However, even though current digital technologies support online classes resulting in a loss in students' academic performance, it is hard to conclude that the digitalization of education has failed and should not be pursued at all [11]. It is hypothesized that new emerging digital technologies will provide an enhanced sensory experience to students in online classes, which will help the tutor engage with the students, resulting in a novel learning experience and higher academic performance [12].

The emerging new digital technologies, such as mixed reality which is defined as the merging of the physical environment with a computer-generated one [13], have huge implications for changing both remote and on-site learning [14]. In remote learning mode, mixed reality would compensate for the loss of learning through the sensory organs by providing a sensory learning experience which is in fact more interactive and enjoyable than on-site classes. It can provide a new learning experience by experimenting with topics and concepts that students often only read about in books but never practice in on-site classes [15]. Such an enhanced experience of learning can bring a new level of enjoyment to classes, which was completely absent in the online learning mode during the pandemic as well as lacking in physical classroom settings [16]. Finally, mixed reality-based technologies enhance interactivity during the learning experience [17]. The mixed reality technologies using features of 3D and advanced graphics do not just give an experience of on-site learning to the students but also help them to engage with elements of experiment within various subjects such as science, mathematics and sociology [18]. Such enhanced interactivity will help the students understand the science behind every learning lesson in the classroom [19].

Further, one of the key outcomes of having learning experiences with mixed reality technology is the satisfaction of students with the content, technology and learning environments [20]. The satisfaction of students always plays an important role in the learning environment. Satisfied students will be actively involved in the learning activities; in addition, such learning activities will ultimately bring a positive academic performance on the part of students. However, the previous literature does not provide a comprehensive examination of the association between both learning experience and satisfaction [21]. Therefore, the present research proposes to include satisfaction as an important outcome of novel learning experiences in the research model.

The uses and gratifications theory can be proposed to be the underpinning theory in the present research. The uses and gratifications theory, especially in the context of technology use, postulates that a user's satisfaction with technology and any consequences (such as students' academic performance) depends upon the use and gratification of the technology [22]. Although the uses and gratifications theory has been widely used in various sets of consumer behavior, its underpinning in emerging and new technologies such as mixed reality and the application of such technology in education is limited. Although various studies have been undertaken by employing uses and gratifications in technology education, its use as a unit of analysis is limited in the research [23–25]. Thus, a gap in research can be observed, which calls for an analysis of the gratifications of technology within the education sector. The present research attempts to fill such a gap by employing novel student experiences as a source of mixed reality gratification.

Although new emerging technologies such as mixed reality promise to bring radical positive change into the learning experience of students [3], research, more specifically research of an empirical nature, is lacking in the academic literature. Some previous research has been undertaken in the context of augmented reality; however, very few researchers have attempted to study mixed reality's impact on the learning experience and students' academic performance [26,27]. Further, empirical evidence on the experiential learning interactivity which mixed reality brings and the students' perception of enjoyment is also completely missing. Therefore, based on the uses and gratifications theory [26], the present research has attempted to examine the role of emerging digital technologies, i.e., mixed reality, in deriving students' novel learning experiences. This learning experience will ultimately lead to higher student academic performance. The present research offers various practical and theoretical implications. The paper is comprised of sections on the literature, research methods, data analysis and the conclusion.

2. Literature Review

2.1. Mixed Reality

Mixed reality is one of the most important and popular emerging digital technologies, combining the features of both augmented and virtual reality [13]. Mixed reality technology attempts to combine virtual and physical space features to create a hybridized simulation of objects in both the physical and virtual worlds [27]. The literature has argued that mixed reality is composed of three crucial components: (a) merging and embedding the physical object into the virtual object; (b) interaction of physical and virtual objects in real-time and (c) creating a map between both the virtual and real object to create real-time interactions between them [28]. Mixed reality technology has huge implications for education [29]. Apart from emerging technologies such as mixed reality, current digital technologies have already impacted the education sector. Trends such as remote learning, online classes and massive online open courses are some pieces of evidence [30]. However, various problems, such as learning experience equivalent to the traditional educational setting, have been lacking. The technology of mixed reality will complement the existing digitalization learning mode by providing learners with both immersive and enjoyable learning experiences [29].

Further, it is important to recognize that the persistent and consistent design decisions made by educators are made according to learning and students' needs. The capabilities of mixed reality, such as spatial visualization, interactive simulations and virtual manipulations, may be used by educators to match educational concepts, learning and students' needs to produce transformational learning experiences that transcend beyond the novelty of the technology's surface level [31–34].

2.1.1. Mixed Reality Learning Enjoyment

The mixed reality learning enjoyment is defined as the extent to which students and teachers feel joy, pleasure and liking while being exposed to content through mixed reality [35]. The empirical research on uses and gratifications theory, such as [22], suggests that the experience of joy, pleasure and liking is a crucial element for people to continue using technology [36]. Thus, it is also argued here that the gratified experience of mixed reality is the key element in the entire application of the technology into the educational sector. Mixed reality technology enhances the experience of joy and pleasure through advanced simulation that provides sensory and emotional experiences to both students and teachers in the classroom [37]. Various empirical evidence, such as [38], has suggested that learning experiences using mixed reality have been phenomenal for students.

Mixed reality-enabled educational delivery has vast implications for the learning and enjoyment experience [39]. It was widely reported that current digital technology, which lacked immersion, created fatigue among both teachers and students and a lack of practical insight and difficulty in the comprehension and processing of educational content [40]. Therefore, mixed reality-enabled educational delivery provides an immediate solution to the problem of fatigue, which is widely reported in the literature with regard to online education. The mixed reality-based educational delivery possesses the unique feature of a virtual and physical continuum in which virtual objects are perceived as more real with the help of a multi-sensory experience [41]. Thus, a mixed reality-enabled virtual and reality continuum will be a critical aspect in enhancing students' learning experience in a remote setting [42]. The immersion will help students to comprehend the educational content, which is necessary for ensuring a good standard of academic performance [43]. Finally, mixed reality-based education is not just of use in the remote or online learning setting; it can also be critical in the on-site learning experience. The empirical evidence suggests that mixed reality already brings enhanced learning experiences in medical and engineering studies through simulation [14].

2.1.2. Mixed Reality Experiential Learning

A pedagogical idea or method known as experiential learning places a strong emphasis on practical learning situations in order to improve comprehension and foster the development of skills [16]. The use of mixed reality in experiential learning can improve the learning process by allowing students to participate more actively and dynamically with challenging subjects [44]. The learning outcomes, motivation and performance of students in science classrooms can be significantly enhanced by using mixed reality technologies and its immersive environment [45]. Past research has consistently demonstrated that an immersive and experiential learning environment can significantly enhance the comprehension and understanding of the complex of scientific concepts and ideas. Further, it has also been demonstrated in the previous research from the cognitive perspective that mixed reality can also be a potent tool that can help students in improving their understanding and recall of scientific concepts by actively involving them in hands-on experiences and simulations [46]. In the research, students explored the structure and operation of cells using mixed reality, and they expressed higher engagement and interest in the subject matter than their counterparts who utilized conventional teaching techniques. In addition, research by [17] discovered that the usage of mixed reality simulations enhanced the clinical reasoning and decision-making abilities of medical students. A mixed reality simulation was employed in the study to model a patient situation, and it was discovered that students who used the simulation outperformed those who received traditional teaching on diagnostic tests. Moreover, vocational training has employed mixed reality experiential learning. Mixed reality simulations were utilized in research by [47] to teach car mechanics, and it was discovered that the simulations increased students' ability to identify and fix issues. According to the study, mixed reality simulations are especially good at teaching students how to operate sophisticated high-tech systems that are challenging to model using conventional training techniques. Overall, the research shows that mixed reality experiential learning has the potential to be a successful and interesting method of teaching challenging ideas and abilities [29].

2.1.3. Mixed Reality Learning Interactivity

With increasing opportunities for natural and intuitive interaction with virtual objects, the use of mixed reality in experiential learning has the potential to improve the learning process [14]. Mixed reality enables students to interact with the learning environment and actively engage in the learning process, and interactivity is a crucial component of mixed-reality experiential learning [48]. In an investigation of the effects of interactive mixed reality on learners' cognitive load and learning results in comparison to conventional teaching strategies, the study indicated that interactive mixed reality lowered cognitive burden and enhanced learning results [49]. Training for high-risk areas is another area where mixed reality experiential engagement has shown promise [23]. The study also discovered that learners were better prepared for high-stress scenarios with mixed reality simulations than with conventional classroom education. Cultural heritage education has also made use of mixed reality experiential engagement. Mixed reality research by [24] used a museum environment to create an interactive learning experience. According to the study, the interactive mixed reality experience increased learners' interest in and pleasure of the museum exhibits and offered a more memorable and immersive learning environment than standard museum visits. Further, the metaverse can also be explored with respect to interactivity as mixed reality can contribute to the metaverse environment [50]. The combination of mixed reality and the metaverse in education brings subjects to life, enabling students to immerse themselves in realistic simulations, historical reenactments, or interactive storytelling experiences [51]. It fosters active engagement and empowers learners to explore concepts at their own pace, boosting motivation and knowledge retention [52].

2.2. Novel Learning Experience

The novel learning experience is based on the experiential learning theory, which posits that the learning process must involve the creation of knowledge itself [25]. The novel learning experience involves the conversion of real-life experiences with the knowledge resulting from an amalgamation of understanding and experience transformation [53]. The novel learning experience requires time in the era of artificial intelligence and digitalization, and the old learning experience is becoming more and more obsolete [54]. To bring the novel learning experience into manifold reality, it is necessary to employ new modern and emerging technologies such as mixed reality [55,56]. Mixed reality using advanced simulation of virtual and reality simulation provides practical insight and experience of the topic being taught to the students in the class [16]. Various disciplines, such as engineering and medical science, are increasingly using mixed reality technologies to demonstrate experiments which have been previously impossible in the classroom setting. Further, technologies such as mixed reality have made the simulation of practical insight in the classroom highly cost-effective [57]. All in all, mixed reality has also made remote and online learning activities not just interactive using the multi-sensory experience but more effective in terms of practical insight being given to students.

H1. *There is a positive and significant relationship between mixed reality experiential learning and novel learning experiences.*

H2. *There is a positive and significant relationship between mixed reality learning enjoyment and novel learning experience.*

H3. *There is a positive and significant relationship between mixed reality learning interactivity and novel learning experiences.*

2.3. Satisfaction

The construct of satisfaction has long been used in the academic field of marketing. However, it is being used in various other academic fields, such as education, to understand the behavior of students and learners, specifically in the context of the content, technology and facilities provided by educational institutes [58]. In the context of technologies such as mixed reality, the author of [59] posits that its wider adoption and required consequences, such as academic performance, depend entirely upon the users' satisfaction. Thus, it can be argued that satisfaction is a prerequisite for understanding desired continued behavior, such as customer loyalty in marketing and continued academic performance in education [60]. Satisfaction can be defined as the ability of products, services and technologies to fulfill specific needs, such as learning [61]. The present research, based on the insight from the uses and gratifications theory, hypothesizes that the satisfaction of students will be yielded from novel student experiences [62]. The novel student experiences are behaviors in which students create new knowledge by using their experience to provide immediate gratification [43]. Students' ability to clear doubt, turn their imagination into reality and perceive experiments and observation working in a way he/she is being taught will help them to build their knowledge and expertise in the subject [16,17,38–52]. Such knowledge and expertise, which is possible due to novel learning experiences using mixed reality, creates a sense of satisfaction in students' minds. Further, such satisfaction will be a source of motivation for students to convert such a novel learning experience into sustained academic performance over a longer period of time. Thus, present research hypothesizes that,

H4. *The novel learning experience has a positive and significant impact on the satisfaction of students.*

2.4. Student Performance

Student academic performance is a widely researched construct in education management and behavior research [63]. Most of the interventions from academic researchers and policymakers in education are designed to measure, capture and assess students' academic performance [64]. The increasing academic performance of students is often referred to as a return on investment in education [65]. Although the students' academic performance is a popular term in educational research, there is a lack of consensus on the widely accepted and singular definition of the students' academic performance. Among educational scholars, terms such as "performance," "accomplishment," and "success" of students are frequently employed interchangeably to point out students' academic performance [66,67]. "Despite this lack of consensus, academic achievement, competencies, and persistence have been used as separate, although interrelated, measurements to assess students' academic performance in higher education" [65]. Despite such a lack of consensus, the present research attempts to define students' academic performance as students' achievement of long and short-term educational goals [68].

The present research theorizes that student satisfaction with the novel learning experience gained from using mixed reality will enhance students' academic performance [16,17,40–50]. The novel learning experience helps students build their knowledge and competencies in a particular subject. Such knowledge will help students develop skills, competencies and expertise to achieve long-term and short-term educational goals [55]. Satisfaction with the learning experience also plays a vital role in-between novel learning experiences and students' academic performance [56]. Generally, students' academic performance is measured both qualitatively (such as motivation and behavioral change) and quantitatively (i.e., GPA). Thus, to convert and transform their learning experience into tangible student academic performance, student satisfaction is necessary [64]. Student satisfaction will push the students to become motivated towards using the knowledge gained from learning experience to bring both positive change into their behavior and achieve higher grades in the academic degrees. Thus, the present research hypothesizes that,

H5. *There is a positive and significant relationship between student satisfaction with learning experiences and academic performance.*

3. Conceptual Framework

This research study employs quantitative analysis to examine the impact of mixed reality on students' learning experiences. The study utilized partial least squares structural equation modeling (PLS-SEM) as a data analysis tool to analyze the collected data. The conceptual framework for the study is presented in greater detail in Figure 1.

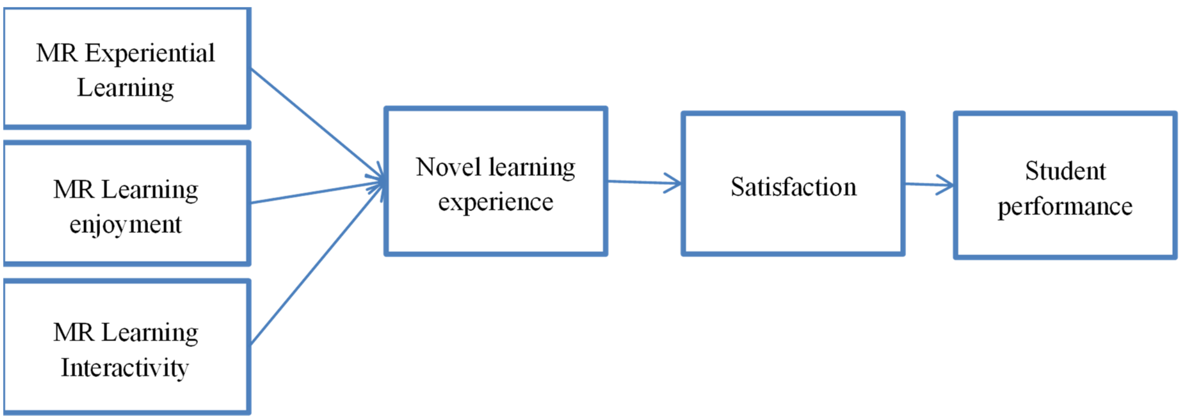

Figure 1. Conceptual framework.

4. Research Methodology

4.1. Research Design

The present research has employed the quantitative research design in which direct and indirect causal effects of mixed reality experiential learning, enjoyment and interactivity will be assessed on novel learning experiences, satisfaction and students' academic performance. The quantitative research design is used in assessing and testing the causal hypothesis. The present research has employed the survey questionnaire as a tool of data collection in which measures of the construct used in the present study have been adopted from the previous research [69]. The present research has employed the partial least square structural equation modeling as a tool for data analysis [70].

4.2. Data Collection

The present research has employed the survey questionnaire as the instrument of data collection. The survey questionnaire data collection instrument is consistent with the present research's quantitative and causal research design [71]. The survey questionnaire employed in the present research has helped to collect the data on the demographic characteristics of respondents, respondents' knowledge and information on the use and application of mixed reality in the educational context, and finally, items and measures on the theoretical constructs of the present research. The items which measure the theoretical constructs are adopted from previous completed research. Table 1 shows the number of items used to measure each construct and its source.

Table 1. Measure in Data Collection Instrument.

S/N	Construct	No. of Items	References
1.	Mixed Reality Experiential Learning	5	[72–74]
2.	Mixed Reality Learning Enjoyment	5	[75,76]
3.	Mixed Reality Learning Interactivity	6	[77]
4.	Novel Learning experience	8	[78]
5.	Satisfaction	5	[79]
6.	Student Academic Performance	4	[80]

4.3. Sampling and Population

The present research aim is to understand the role of mixed reality in driving learning experiences, satisfaction with these tools and enhancing students' academic performance. The present research has based its empirical consideration on Saudi Arabia. So, the population of the current study is all those students in various academic and educational institutions in Saudi Arabia who have been exposed to mixed reality from their respective institutions. The present research has employed two-stage non-probability purposive convenience sampling techniques to collect the data from the population of the current study [81]. The non-probability sampling technique is used as researchers do not have exact information on the number of students who have been exposed to mixed reality in Saudi Arabia and the number of institutions that have used such technologies. The present research has employed G*power software to determine the sample size for the current study. G*power is a widely used sample determination tool in survey research [82]. The results from G*power suggests that a sample of 280 will be appropriate for the current study.

4.4. Data Analysis Tools and Techniques

The present research has employed structural equation modelling (SEM) as a tool for data analysis. The literature suggests that there are two different techniques of SEM, which include covariance-based SEM and variance-based or partial least square SEM (PLS-SEM). The CB-SEM is a parametric technique which requires both probability sampling and normality as assumption [83]. However, the present research has employed non-probability sampling which has led us to the development of non-normal data and it is suggested that non-parametric PLS SEM needs to be employed [84]. The PLS-SEM is a powerful data analysis tool that is being widely adopted by researchers studying behavior in education [85]. The data analysis using the PLS-SEM consists of two main steps, i.e., testing the measurement model assessment and testing the structural model assessment. The test of the measurement model is used to establish the reliability, validity (both convergent and discriminant) and variance explained in the model and model fitness of the conceptual framework [86], while the structural model assessment is used to undertake the hypothesis testing and conclude the final results of the study [87].

5. Results

The present research aims to understand the causal effect of using mixed reality in education through variables such as students' novel learning experiences, satisfaction and performance. The present research using an instrument survey questionnaire collected data from students in Saudi Arabia.

5.1. Demographic Analysis

Table 2 below presents the demographic information of the sample of the present study. The results of the demographic information show that the majority of the sample of the present study was male (63.7%) from a gender perspective, and the rest was female (36.3%). From an age point of view, the sample was diverse and represented the age group in a better way. The age group from 16 to 18 years was 8.3%. The low participation of this age group can be attributed to various reasons, such as comprehension of items on the questionnaire and easy access to them. The age group from 19 to 21 was higher in number (almost 39%). The age group of 22–25% was the second highest in number (almost 29%). The age group of 25–28 (15%) and 29 and above (almost 9%) were appropriate in size as the majority of people in this age group have left academia and joined industry for the purpose of career development.

Table 2. Demographic Analysis.

Gender		
	Male	63.7%
	Female	36.3%
Age		
	16–18	8.3%
	19–21	38.9%
	22–25	28.9%
	25–28	15%
	29 and above	8.9%
Education Level		
	High School	8.3%
	Under graduation	38.4%
	Post Graduation-Masters	26%
	Post Graduation-Doctoral	12.7%
	Vocational	14.6%

5.2. Construct Validity and Reliability

The present research assessed the reliability of constructs using the statistical tests available in the partial least square structural equation modelling (PLS-SEM). These tests include both the Cronbach's alpha [88] and composite reliability [89]. According to [90], to assume that each construct of research has achieved its construct validity, the value of both the Cronbach's alpha and composite reliability should be at least 0.70. From the results shown in Table 3, it can be concluded that the present research has achieved construct reliability as each construct has reported a value above 0.70 on both the Cronbach's alpha and composite reliability. Construct validity is referred to as the assumption that the construct measures their unique and distinct phenomena in the research model [91]. According to [90], construct validity can be assessed using PLS-SEM through average variance extracted (AVE). They further argue that to assume that each construct has achieved validity, the value of AVE should be at least 0.50. The results conclude that each construct in the present research has achieved validity based on the threshold value of AVE.

Table 3. Construct validity and reliability.

Parameters	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
Mixed reality experiential learning	0.887	0.947	0.899
Mixed reality learning interactivity	0.819	0.895	0.740
Mixed reality learning enjoyment	0.903	0.928	0.720
Novel learning experience	0.913	0.933	0.702
Satisfaction	0.882	0.913	0.678
Student Performance	0.962	0.972	0.898

5.3. Discriminant Validity

The discriminant validity in the PLS-SEM can be defined as the extent to which a construct in the regression model is unique, and it does not measure another phenomenon or construct in the same model [92]. The discriminant validity is an important criterion to assess the uniqueness of each construct in the regression model [93]. The present research has employed the test of the Fornell–Larcker criterion to assess the discriminant validity. The literature suggests that the Fornell–Larcker criterion of each variable must be higher than their value on other constructs [94]. The results, as shown in Table 4, depict that each construct has a higher Fornell–Larker criterion by themselves as compared to others.

Table 4. Discriminant validity.

Constructs	MEL	MRLA	MRLE	NLE	S	SP
MEL	0.948					
MRLA	0.595	0.860				
MRLE	0.808	0.741	0.848			
NLE	0.770	0.671	0.788	0.838		
S	0.504	0.581	0.627	0.727	0.823	
SP	0.311	0.486	0.468	0.526	0.803	0.948

5.4. Indicator Outer Loading

In the same way as construct reliability, the indicator reliability test in PLS-SEM assesses the internal consistency of each of the items in the research model with their constructs. The PLS-SEM helps the researcher to assess the indicator reliability using the test of outer loading [83]. According to Hair [90,95], the value of overloading should be at least 0.70 to assume that each item is internally consistent with its constructs. The results of outer loading are presented in Table 5, showing that each item has reported an outer loading value of at least 0.70. However, it is worth mentioning here that items whose outer loading value was below 0.70 were removed from further analysis.

Table 5. Outer loading.

	Items	Outer Loading
Mixed Reality Experiential Learning	MEL4	0.947
	MEL5	0.949
Mixed Reality Learning Interactivity	MLI1	0.750
	MLI3	0.914
	MLI4	0.907
Mixed Reality Learning enjoyment	MLE2	0.841
	MLE3	0.812
	MLE4	0.874
	MLE5	0.879
	MLE6	0.835

Table 5. *Cont.*

	Items	Outer Loading
Novel Learning Experience	NLE2	0.851
	NLE3	0.880
	NLE4	0.900
	NLE5	0.870
	NLE6	0.796
	NLE7	0.715
Satisfaction	S1	0.846
	S2	0.827
	S3	0.865
	S4	0.784
	S5	0.793
Student Performance	SP1	0.950
	SP2	0.954
	SP3	0.933
	SP4	0.954

5.5. Variance Explanation-R Square

The variance refers to the disbursement of the data from their mean point in the research model. The social science researcher tends to assess the variance using the statistical test of R square. The R square assesses the contribution of the variance of each independent variable to the dependent variable of the research model [96]. The results, as shown in Table 6, concludes that factors of mixed reality, which include experiential learning, enjoyment and interactivity in combination, contribute 68.9% variance in the novel learning experience. The novel learning experience contributes 52.8% to satisfaction. Finally, satisfaction contributes a 64.5% variance in students' performance.

Table 6. Explanation of variance.

	R Square	Adjusted R Square
Novel Learning Experience	0.689	0.686
Satisfaction	0.528	0.527
Student Performance	0.645	0.644

5.6. Model Fitness

The present research employed the Standardized Root Mean Residual (SRMR) as a measure to assess the fitness of the research model. The literature suggests that a value of SRMR close to 0.80 means the research model can be considered to have achieved its adequate level of fitness [97]. The results, as shown in Table 7, shows that the value of the SRMR of the present research is 0.809, so it can be considered that the present research has achieved the model fitness.

Table 7. Model Fitness.

	Saturated Model	Estimated Model
SRMR	0.809	0.814

5.7. Conceptual Model

The results depicted in Figure 2 illustrate the measurement model used to evaluate the academic performance of Saudi students based on their novel learning experiences and satisfaction of mixed reality.

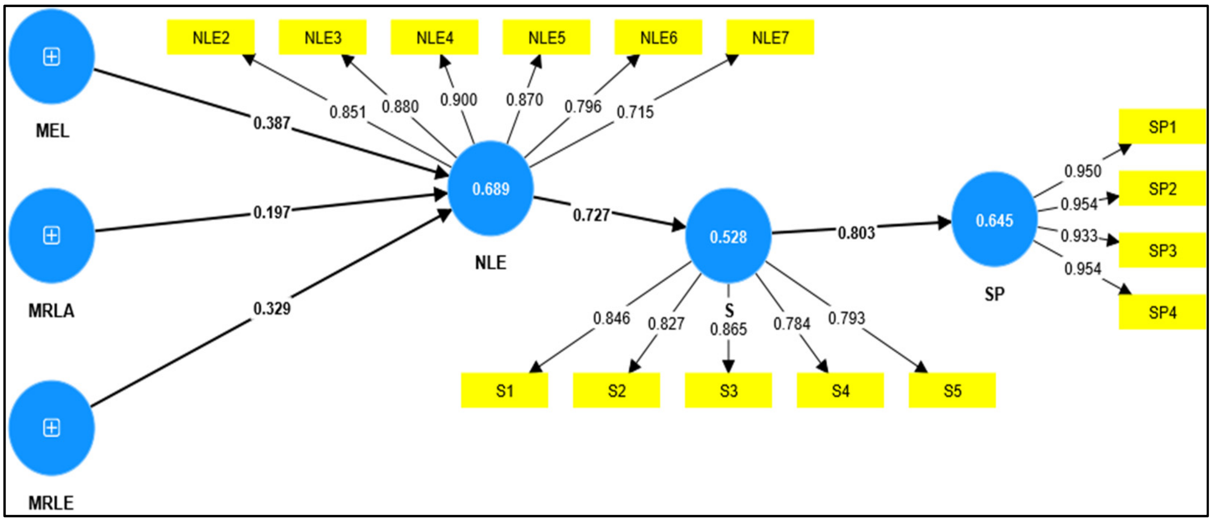

Figure 2. Measurement and conceptual model.

5.8. Structural Model

The present research calculated a structural model based on the bootstrapping procedure in PLS-SEM using the Smart PLS 4. The results of both direct and indirect effects are presented in Table 8. The results show that every hypothesis has been accepted based on a p-value of less than 0.05.

Table 8. Structural model.

Hypothesis	Path Co-Efficient	T Statistics	*p* Values	Decision
Mixed reality experiential learning → Novel learning experience	0.387	6.647	0.000	Accepted
Mixed reality learning interactivity → Novel learning experience	0.197	3.605	0.000	Accepted
Mixed reality learning enjoyment → Novel learning experience	0.329	4.527	0.000	Accepted
Novel learning experience → Satisfaction	0.727	24.064	0.000	Accepted
Satisfaction → Student Performance	0.803	56.082	0.000	Accepted
Indirect Effects				
Novel learning experience → Satisfaction → Student Performance.	0.584	20.483	0.000	Accepted
Mixed reality experiential learning → Novel learning experience → Satisfaction	0.239	4.398	0.000	Accepted
Mixed reality learning enjoyment → Novel learning experience → Satisfaction	0.281	6.612	0.000	Accepted
Mixed reality learning interactivity → Novel learning experience → Satisfaction	0.143	3.512	0.000	Accepted

6. Discussion

The present research is aimed at understanding the role the emerging digital technology of mixed reality can play in the education sector, particularly in students' learning experience. The present research, drawing insight from prior research, has theorized that mixed reality can enhance students' learning experiences in three different ways. First, mixed reality can enhance the experiential learning experience; second, it can enhance overall interactivity with learning objects and subjects and finally, mixed reality can enhance the overall enjoyment of the learning experience, which is still missing in the physical classroom setting. The research further theorizes that novel student learning experiences can impact students' satisfaction with both mixed reality technologies and the overall learning environment, and that such satisfaction will yield to the students' academic performance.

6.1. Mixed Reality

The present research hypothesized that aspects of mixed reality in a learning experience which include experiential learning, enjoyment and interactivity, have a positive and significant impact on students' novel learning experience. The three hypotheses have been accepted based on the p-value below 0.05. Experiential learning is said to be the pedagogical approach in educational science which stresses learning through hands-on and practical experience. The phrase "learning by doing" can better be illustrated for experiential learning. Experiential learning can provide a novel learning experience to the students through hands-on practical exercises and approaches. However, in complex subjects such as physics, biology and chemistry, experiential learning has been limited in scope due to various infrastructural constraints. However, with the emergence of mixed reality such constraints are no longer applicable [14–43]. The results from the present research's empirical evidence show that mixed reality-enabled experiential learning has a positive impact on students' or learners' novel experience of learning ($p = 0.000$). The results further conclude that mixed reality learning can play an important role in implementing the idea of experiential learning and can significantly aid in the novel learning experience directly ($\beta = 0.387$) and satisfaction with the learning environment and technology indirectly ($\beta = 0.239$, $p = 0.000$).

The education researchers, along with experiential learning, also emphasize the role of students' interactivity with learning objects and learning environment. The interactivity with the learning objects and environment always makes the learner more proactive in the learning approach. However, interactivity, in the same way as experiential learning, is limited due to various constraints. In subjects such as biology, students need to interact with all the instruments of a lab to make sense of a concept. Mixed reality using 3D and advanced graphics technology allows the students to interact with the instrument in the virtual–physical continuum [16–47]. The results of the current study also support such assertions as it shows that mixed reality-enabled interactivity in learning has a positive impact on students' or learners' novel experience of learning ($p = 0.000$). The results further conclude that mixed reality learning can play an important role in enhancing students' interaction with the learning subject, objects and environment, and such interaction can enhance students' novel experience directly ($\beta = 0.197$) and students' satisfaction with learning objects, subject and environment indirectly ($\beta = 0.281$, $p = 0.000$).

Finally, it is argued by experts that learning must contain the element of enjoyment. Learning is the process that equips learners with skills and information that can be useful for various aspects of life [48]. It is also argued that real learning takes place with a change in the behavior and lifestyle of the learner. Therefore, learners, upon observation of such a change in behavior, skillset and lifestyle, feel enjoyment. However, the current system of education with traditional resources does not allow the learner to enjoy their learning process [23]. However, with the emergence of mixed reality, the element of learning can be introduced successfully. The mixed reality using the element of digital objects, the virtual–physical continuum and experiential learning can provide a feeling of enjoyment. Such results have been provided in the empirical evidence of the present research study. The present research results conclude that mixed reality-enabled learning can bring enjoyment and novel learning experiences to learners ($p = 0.000$, $\beta = 0.329$). The results further conclude that mixed reality learning which enables learning enjoyment can also improve students' satisfaction with learning objects, subjects and environment indirectly ($\beta = 0.143$, $p = 0.000$).

6.2. Satisfaction

The present research has hypothesized about the satisfaction of the students and learners with mixed reality and learning environments. The literature suggests that students actively and successfully learn in a situation where he/she is satisfied with facilities, subjects, objects and other environmental elements [16,17,38–62]. The present research theorized that student/learner satisfaction could be obtained directly from students' novel learning experiences. The novel learning experience is explained as a learning experience that provides students with the idea of experiential learning, interactivity with the subject, object and environment of learning and enjoyment. The results of the present research's empirical analysis have confirmed such theorization ($p = 0.000$). The results have concluded that novel learning experiences can play an instrumental role in satisfaction directly, and mixed reality elements such as interactivity, enjoyment and experiential learning can yield it indirectly.

6.3. Student Academic Performance

Finally, the present research has theorized about students' academic performance in present empirical research. Students' academic performance, which has suffered due to the COVID-19 pandemic and has been continuously suffering during the digitalization of education due to a lack of interactivity and sensory experience [64], has been a fruitful and important area of research. The present research theorizes that current digital technologies and their application in education, such as video-conferencing software, classroom digital projectors and various other tools, are lacking in their infrastructural capacity suited for education [65]. However, the emerging digital technology of mixed reality has the capacity and infrastructure to digitalize education in a positive way that enhances students' learning and experience. The present research theorizes that mixed reality can create a novel learning experience that has a direct and significant impact on satisfaction and an indirect and significant impact on students' academic performance. The present research has also hypothesized that satisfaction, on the other hand, has a direct impact on students' academic experience [16,17,40–67]. The results of PLS-SEM analysis have confirmed our theorization that satisfaction has a direct and significant impact ($\beta = 0.803$, $p = 0.000$) and that novel learning experience has an indirect ($\beta = 0.584$, $p = 0.000$) impact on the students' academic performance.

7. Conclusions

Emerging technologies such as artificial intelligence, mixed reality, robotics, chatbots and extended reality have started to disrupt various aspects of human lives. The field of education has also been affected by these technologies in a dramatic way. The technology of mixed reality promises to bring positive changes in the education sector in various ways, such as the delivery of teaching, development of effective content, diffusion of distance learning and others. Apart from these positive changes, one of the key revolutions it promises to bring is in students' learning experiences which can enhance their academic performance. The era of the COVID-19 pandemic has negatively affected student learning all over the world. The public health protective measures required the government to shut down schools, colleges, universities and other educational institutes and such steps virtually suspended learning activities. The digital solution, such as video conferences software packages such as Zoom, Microsoft Teams and Google Meet, offered a temporary solution but various problems, such as digital fatigue, lack of interactivity and lack of adequate learning experience, were reported. However, these and other tools introduced the concept of digitalized education worldwide. Therefore, new tools are required that effectively solve problems that have not just emerged in the digitalized educational setting but in the physical or on-site education setting as well. The present research, which aims to fill such an important gap in the literature, has studied the role of mixed reality, a promising technology that can revolutionize education.

The current research attempts to study and investigate the role that mixed reality can play in the educational setting. The present research theorizes three different roles which it can play in the educational setting based upon insights deduced from the literature. These roles include; developing experiential learning methods, enhancing interactivity with learning objects, subjects and environments in both digital and physical classroom settings, and enjoying what can be brought into the experience of learners or students. The research further examined such roles of mixed reality in the development of novel learning experiences, satisfaction and, ultimately, students' academic performance. The results found that mixed reality embedded experiential learning, interactivity and enjoyment can directly enhance a student's novel learning experience and indirectly enhance the student's satisfaction with learning objects and environment.

The present research offers to complement the ongoing efforts of the digitalization of education. The digitalization of education is not just cost-effective, but it also solves some of the basic problems of education, such as access to education in remote areas, making education affordable, accessible and open to every student. Further, technologies such as mixed reality can make education a fun activity in which students can experience concepts and learning points directly. The technology of mixed reality opens new features of making education more enjoyable and interactive in nature. It can improve student satisfaction with the overall educational facilities and infrastructure. Finally, it can enhance students' academic performance.

7.1. Theoretical Implication

The present research offers two sets of theoretical implications. The theory of uses and gratifications has provided important theoretical guidelines to examine and understand the adoption and diffusion of technology. Most of such research has been undertaken in a commercial setting in which users of technology were consumers. The application of uses and gratifications has been limited in the educational setting in which technology users are not considered consumers but important stakeholders. Thus, the present research offers important empirical evidence on the role of uses and gratifications theory in the educational setting in which users of technology are considered stakeholders. Secondly, the present research confirms the empirical underpinning of uses and gratifications theory in the context of emerging technologies such as mixed reality technologies. Although research is being undertaken on the empirical aspect of mixed reality, the present research is the pioneer in developing empirical evidence on mixed reality use in Saudi Arabia.

7.2. Practical Implication

The present research offers various kinds of policy implications. First, the results of the current research study have provided some valuable evidence which can support the process of the digitalization of education. The present research study contributes to the growing body of literature which highlights the role of technology in enhancing educational experiences. However, it is essential to prioritize pedagogy before technology and consider the study's findings as additional evidence rather than a call for immediate policy implications to digitalize education. Second, the present research offers conclusions on the role of emerging digital technologies, more specifically mixed reality, and argues that such technologies will play a greater and wider role in the educational setting by enhancing the student learning experience as well as academic performance. Finally, the present research offers policymakers guidelines to focus on the aspect of education that can be targeted with the help of digital technologies, and these include learning experience, satisfaction and students' academic performance.

Further, mixed reality in education provides various implications for leaders as well. University leaders should prioritize strategic planning by acknowledging that mixed reality may enhance student learning. Educational innovation plans can allocate resources and plan their implementation across disciplines. Secondly, the implementation of mixed reality requires infrastructure and proper investment by university leaders, which would entail proper equipment, software, and networks. By assessing the institution's technology and infrastructure, leaders can ensure mixed reality is well integrated and utilized. In addition, university administrators should foster partnerships with IT companies, schools, and industry professionals. Sharing ideas, knowledge and innovations can promote mixed reality integration. These connections can help leaders design mixed reality education technologies.

Finally, Saudi Arabia's distinct cultural and societal factors have an impact on the use of mixed reality technology in its education sector. Recognizing the need to modify technology to conform to regional norms and traditions is crucial for applying these lessons to other nations. The localization of the language used in mixed reality apps in Saudi Arabia should be given priority, and care should be taken to ensure that it is consistent with Arabic, the nation's official language. Students' learning experiences will be improved as a result, which will promote higher comprehension and engagement. Additionally, university administrators must aggressively encourage the community's understanding and acceptance of mixed reality technology. They can promote a good impression of the technology and encourage participation from students, parents and other stakeholders by setting up workshops, seminars and educational campaigns. Collaboration with governmental organizations, business partners and educational institutions may also aid in the exchange of best practices and experiences, resulting in the ongoing development of digital technologies to improve the educational experience of students. These initiatives ought to be directed at developing a welcoming and encouraging atmosphere that welcomes technological innovation and encourages academic performance.

7.3. Limitation and Future Research Recommendations

The present research has various limitations and provides future research recommendations. First, the sample of the present research study was limited to the context of Saudi Arabia. However, future research looking at the wider generalizability to the region of the Middle East should collect samples from other countries in the region, such as the United Arab Emirates and Qatar, who are also actively using these tools and techniques in their education sector. The present research has attempted to employ the survey and structural equation modelling as part of the research design. However, future researchers can include a randomized control trial as the methodology in the research design. Thirdly, new emerging digital technologies such as chatbots and the metaverse can be focused on education by replicating the core concepts espoused in the present research. Finally, other theoretical contexts, such as the Technology Acceptance Model (TAM), can also be a focus of future research along with uses and gratifications theory.

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