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Assessing the Effectiveness of Virtual Reality Simulation in ICT Education: A Study Based on the Technology Acceptance Model

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Abstract: ***This study aims to establish the applicability of VR in studying ICT. This research aims to establish whether VR influences learning outcomes, learners' motivation and attitudes positively. It measures the perceived benefits of using VR including the extent to which students consider the technology useful in enhancing learning.***
Structural equation modeling was employed by administering a quantitative survey with 191 participants, students, and instructors teaching ICT classes with the use of VR. Data analysis was done with the help of SPSS and AMOS; EFA and CFA were used to validate the constructed constructs. There was a strong positive correlation between PEOU and PU, which corroborates the fact that ease of use of the VR tool has positive implications on perceived usefulness and the formation of a positive attitude toward virtual reality learning by design. The findings of this study will be a rich resource for educators, curriculum developers, and policymakers who aim to use VR to enhance education in the digital age.

Keywords: ***Virtual Reality, VR, Application of Immersive, Digital Age, Simulation Platform, Non-Immersive.***

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1. INTRODUCTION

Technology and education work together in a synergistic way that is changing the world with every advancement achieved from both viewpoints. The educational landscape exhibits a reluctance to embrace rapid change, with teaching approaches and techniques evolving at a more gradual pace whereas technology keeps changing at a rapid pace.
Virtual reality (VR) is a simulation platform that allows users to experience a three-dimensional (3D) environment in a realistic manner using suitable technologies (Linowes, 2015). Virtual reality technologies were introduced in the 1980's and are grouped under two categories thus immersive VR and non-immersive VR desktop, depending on the type of experience they provide.
The adoption and application of VR have contributed immensely to the field of education because of its high level of interactivity by providing hands-on experiences (Brewer et al, 2015). In other fields, VR is being used to deliver educational content alongside the traditional methods of teaching (Marougkas et al, 2023).VR is best used in teaching topics that are abstract and difficult to comprehend. According to (Abdullah & Asmaa, 2024) VR can improve motivation and attention, reducing the burden of teaching and training and additionally making up for the deficiency of conventional teaching methods. Their study also affirmed that VR integration will radically change various educational systems, and researchers can take advantage of the extracted VR learning data to provide improvement and assistance to learners, educators, educational institutions, and the learning environment.
The Technology Acceptance Model, which was first created by Davis, is a highly useful framework for comprehending how people come to embrace and use technology. According to TAM, perceived utility and perceived ease of use are two of the main elements determining attitudes towards any given technology, which in turn influences consumers' intentions to utilise it. These elements become crucial in predicting whether or not students would accept VR simulations as a teaching tool when it comes to VR in ICT education.
Therefore, this work aims to extend the Technology Acceptance Model investigating on the usage of VR within ICT education. In general, the TAM is useful to consider more in detail how exactly individuals conceive of and come to embrace new technologies with regard to time use utilization and use-value aspects in particular.

1.1 Objectives

- To examine the relationship between the perceived usefulness of VR simulations and the perceived ease of use of VR in ICT education.
- To investigate the impact of perceived ease of use on students' attitudes towards the use of VR in ICT education.
- To assess how a positive attitude towards VR simulations affects students' intention to use VR in ICT education.

Research Questions

1. How does the perceived usefulness of VR simulations influence the perceived ease of use of VR in ICT education?

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2. What is the impact of perceived ease of use on students' attitudes towards the use of VR in ICT education?
3. How does a positive attitude towards VR simulations affect students' intention to use VR in ICT education?

1.2 Hypothesis

- H1a: The more useful that the VR simulations are perceived to be, the more positive is the perceived ease of use of VR in ICT education.
- H2a: If the perceived ease of use of the VR simulation is higher, then the attitude towards the use of VR in ICT education will be more positive.
- H3a: The more positive the attitude towards the use of VR simulations, the higher the intention to use VR in ICT education.
- H4a: The more VR simulations are perceived to be easy to use, the stronger the intention to use by students.
- H5a: The higher the Social norms, the higher the intention to use.
- H6a: Higher motivational support is related to a higher intention to apply VR simulations in ICT education.
- H7a: The higher a system is perceived to be easy to use the higher the students are motivated to use the system.

2. RELATED WORK

Introduction to ICT Education and the Role of Virtual Reality

Information and communication technology education has evolved with the introduction of virtual reality into immersive, interactive learning and AI in general (Gyan Darling et al., 2024), which no other traditional techniques can provide. Virtual reality technology helps students understand complicated concepts and remember them by directly interacting with the material through simulation in three-dimensional worlds (Dr. Bindu & Subin, 2024; Maqableh et al., 2024). Virtual reality in education enhances creativity, critical thinking, and problem-solving skills very major qualities of any workforce that exists in the twenty-first century (Abdul Rahman et al., 2023). It also allows students to conduct experiments or explore settings which would, in reality, be impractical, thus bridging the gap between theoretical knowledge and its practical application via VR (Zhang et al., 2020); (Maqableh et al., 2024).
ICT has increasingly become integral to 21st-century education and supports dynamic learning for the provision of digital competencies among students. The role of VR in the simulation of real scenarios lets students intuitively and interactively involve themselves with the complex concepts of ICT, which may enhance comprehension and retention. (Radianti et al., 2020).

2.1. Theoretical Framework: Technology Acceptance Model

TAM was formulated by Davis in 1989 and for several years it remains as one of the most widely used theoretical models for understanding the acceptance and usage of new technology. According to TAM, two critical factors are believed to affect users' acceptance of technology: Of the two factors, PU and PEOU are more important to IS use. The distinction between the two, specific and overall perceived ease of use, is in the extent to which an individual feels that

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using a particular system will increase performance and reduce effort. Venkatesh and Davis, 2000 advanced that these factors in turn determine the attitude of the user towards using the technology which is also the case with the behavioral intention and actual use of the technology.

2.2 Effectiveness of VR in ICT Education

The integration of Virtual Reality (VR) with Information and Communication Technology (ICT) has received a lot of attention in recent years, especially in the way it supports learning objectives, learning motivation and performance. Through VR, ideas are learned through simulation, and teaching is done through activities that give an understanding of specific ideas that are hard to grasp (Dr. Bindu & Subin, 2024; Sakr & Abdullah, 2024). Research evidence points to the fact that as a result of VR, students may be motivated to develop a positive attitude towards the learning process since they apply knowledge in an actual manner by viewing models of their real-life applications or through simulation (Sakr & Abdullah, 2024; Abdul Rahman et al., 2023).

Literature has established that ICT education in particular has been subject to a number of research studies that seek to determine the efficiency of VR technology in this area with most of them yielding inconclusive findings. First, studies indicate that the use of VR can improve students' learning of and their abilities to grasp and recall difficult to some extent ICT concepts, primarily because VR inspires them to learn through the use of roles (Merchant et al., 2014).

2.4 Technology Acceptance of VR in ICT Education

With TAM, the acceptance of Virtual Reality (VR) technology in Information and Communication Technology (ICT) education is greatly affected by factors that have been elaborated below. Studies show that perceived ease of use and perceived usefulness are essential factors in influencing the students' perceived attitude towards VR thus, their willingness to embrace the technology in their learning process (Puiu & Udris, 2024); (Wong et al., 2023). Existing papers suggest that educational experiences using VR produce higher levels of learning and attention than regular teaching approaches, especially in cases where traditional techniques fail (Abdul Rahman et al., 2023); (Gervasi et al., 2023). In addition, literature, pedagogy, and andragogy show that adopting VR in education has been perceived positively, and students' motivation and critical thinking are enhanced (Abdul Rahman et al., 2023); (Maqableh et al., 2024).

The adoption of TAM in analyzing the acceptance levels of VR in ICT education has thrown more light on the factors that contribute to the students' perceived usefulness of this technology.

3. METHODOLOGY

3.1. Research Design

With the adoption of TAM, this study uses a quantitative research methodology to assess the virtual reality simulation's influence on ICT education. The study is carried out using a structured survey; questionnaires are designed to gather information from teachers and students in ICT courses that use VR simulations.

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3.2. Population and Sample

The study's sampling frame includes both instructors and students involved in ICT education at a particular institution where virtual reality simulations are integrated into the teaching approach. To ensure representation across different levels, stratified random sampling is employed, targeting students from introductory, intermediate, and advanced ICT courses. The sample for this study was 191 participants, reflecting a broad spectrum of perspectives from various sectors.

3.3 Data Collection Instrument

To assess the perceived usefulness (PU), perceived ease of use (PEOU), attitude towards using (ATU), intention to use (IU), motivation support (MS), and social norms (SN) associated with virtual reality (VR) simulations in information and communication technology (ICT) education, a meticulously structured questionnaire informed by the Technology Acceptance Model (TAM) has been developed. The questionnaire is composed of multiple sections:
It covers several areas, including demographic details like age, gender, academic level, and prior experience with VR. It also explores how participants view the usefulness of VR in improving learning ICT and easy use (Davis, 1989). Additionally, attitude towards use, their likelihood of continuing to use it or recommending it to others (Venkatesh & Davis, 2000), motivation to engage with VR and the impact of social norms on their decision to use VR in ICT education.
The items are measured on a five-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree."

Data Collection Procedure

The questionnaires are distributed electronically through email and online survey platforms. Prior to distribution, a pilot test is conducted with 20 participants to ensure clarity and reliability of the questions.

3.4. Data Analysis

Specifically, SPSS and AMOS are used as statistical tools for data analysis. The demographic information and responses pertaining to the TAM components are summarized using descriptive statistics, such as mean and standard deviation. Regression analysis is used to examine the relationships between PU, PEOU, ATU, MS, SN and IU (Venkatesh & Davis, 2000). Additionally, substantial correlations within the TAM components across different demographic groups are found by the application of Covariance-Based Structural Equation Modelling (CB-SEM)."

3.5. Findings

EFA and CFA Analysis

This research used exploratory factor analysis through the use of SPSS and the confirmatory factor analysis was done through the use of Amos v23. The data thus collected was entered into the SPSS v27 where the correlation matrix was run to check for the multicollinearity. In the EFA, and principal component analysis was used to assess the factor structure. The analysis showed the constructs of the study and their measuring items, namely PU (9), PEOU (5), ATU

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(8), IU (4), MS (5), and SN (9). The rotating component matrix for these items presented here revealed loadings above 0. 5 which from the foregoing is considered reasonable in line with the findings by Costa & Sarmento (2019).

Table 1- Exploratory Analysis

Rotated Component Matrix						
	Component					
	1	2	3	4	5	6
PU1	0.576					
PU2	0.633					
PU3	0.715					
PU4	0.536					
PU5	0.723					
PU7	0.553					
PU8	0.563					
PU9	0.736					
PU10	0.739					
PEOU2					0.673	
PEOU3					0.537	
PEOU5					0.501	
PEOU7					0.549	
PEOU9					0.565	
ATU2				0.699		
ATU3				0.649		
ATU4				0.756		
ATU5				0.683		
ATU6				0.729		
ATU7				0.608		
ATU8				0.755		
ATU9				0.666		
IU4		0.782				
IU7		0.630				
IU8		0.611				
IU10		0.826				
MS2		0.826				
MS3		0.841				
MS4		0.652				
MS6		0.835				
MS10		0.850				
SN1			0.790			
SN2			0.695			

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SN3			0.533			
SN4			0.744			
SN5			0.566			
SN7			0.711			
SN8			0.778			
SN9			0.623			
SN10			0.767			

The suitability of the data to be factor analyzed was first checked through the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity. KMO measures if every variable and the entire model is adequately sampled, which in fact gives the percent of variance in the variables that could be caused by trends. According to Kaiser, the interpretation of KMO values is as follows:

0.90 to 1.00: Marvelous, **0.80 to 0.89**: Meritorious, **0.70 to 0.79**: Middling
0.60 to 0.69: Mediocre, **0.50 to 0.59**: Miserable, **Below 0.50**: Unacceptable

The KMO results for this study are presented in the table below, which suggests that the correlations among variables are adequate for identifying underlying factor structures.

Table 2 - KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.929
Bartlett's Test of Sphericity	Approx. Chi-Square	6116.348
	Df	946
	Sig.	0.000

3.6. Validity and Reliability

Validity is the extent to which a research instrument captures what is wanted or intended to be captured. They make certain that the resulting scores truly represent the idea or variable under research. For example, if a survey were to be conducted for the purpose of measuring student motivation, validity would refer to the ability of the survey to capture motivation and not some other related construct such as interests or engagement (Creswell & Creswell, 2018).

Test reactivity is a close concept to internal consistency therefore it can be defined as the extent to which a research instrument is stable across time. It is an instrument that gives consistent results whenever conditions are repeated in future. This implies that, in case the same research study is conducted under similar conditions, the research instrument will yield the same results every time leading to the conclusion that the measurements taken were dependable (Creswell & Creswell, 2018).

Table 3 - Validity and Reliability Analysis

LATENT VARIABLE	CRONBACH ALPHA	NO OF ITEMS
PU	0.900	9
PEOU	0.844	5

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ATU	0.923	8
IU	0.836	4
MS	0.915	5
SN	0.917	9

Lee J. Cronbach proposed the following guidelines for interpreting the values of Cronbach's alpha (α) as a measure of internal consistency or reliability of a test or scale:

A ≥ 0.9: Excellent, 0.8 ≤ α < 0.9: Good, 0.7 ≤ α < 0.8: Acceptable, 0.6 ≤ α < 0.7: Questionable, 0.5 ≤ α < 0.6: Poor, α < 0.5: Unacceptable.

The Cronbach Alpha (CA) values for the different variables all exceed 0.8α, indicating that the items used to evaluate each latent variable are internally consistent and effectively measure their respective constructs.
A confirmatory factor analysis was conducted to affirm the relationship results from the exploratory factor analysis, confirmatory analysis helps to measure the exact relationships between observed variable and their latent variable and also the relationship between the various latent variables (Li, 2021). The results are displayed in Table 4, figure 1, and Figure 2. The results from the CFA show that all the standardized factor loading for all the latent and observed variables exceeded 0.5 cut off and also the Cronbach alpha exceeded 0.8, AVE was above 0.5 but less as compared to convergent validity necessitates composite reliability (CR) that has a minimum of 0.8 Fornell and Larcker (1981), five constructs attained this criterion

Table 4 – Model Fit measures

Model-fit indices	**loading**	**Factor**
CMIN=1370.418; DF=725; CMIN/DF=1.890; PClose=.000; TLI=.867; CFI=.876; RMSEA=.068; RMR=..089,NFI = .771		
PERCEIVED USEFULNESS: CA=0.900; CR=0.901; AVE=0.503		
PU1		0.67
PU2		0.69
PU3		0.69
PU4		0.73
PU5		0.76
PU7		0.75
PU8		0.66
PU9		0.73
PU10		0.70
PERCEIVED EASE OF USE CA=0.844; CR=0.844; AVE=0.520		
PEOU2		0.72
PEOU3		0.72
PEOU5		0.76

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PEOU7		0.73
PEOU9		0.67
ATTITUDE TOWARD USING : CA=0.923; CR=;0.926; AVE=0.611		
ATU2		0.81
ATU3		0.80
ATU4		0.82
ATU5		0.71
ATU6		0.77
ATU7		0.77
ATU8		0.77
ATU9		0.78
INTENTION TO USE: CA=0.836; CR=0.842; AVE=0.575		
IU4		0.84
IU7		0.68
IU8		0.65
IU10		0.84
MOTIVATIONAL SUPPORT: CA=0.915; CR=0.921; AVE=0.702		
MS2		0.89
MS3		0.88
MS4		0.70
MS6		0.86
MS10		0.85
SOCIAL NORMS : CA=0.917; CR=0.919; AVE=0.559		
SN1		0.83
SN2		0.74
SN3		0.71
SN4		0.72
SN5		0.64
SN7		0.68
SN8		0.80
SN9		0.76
SN10		0.82

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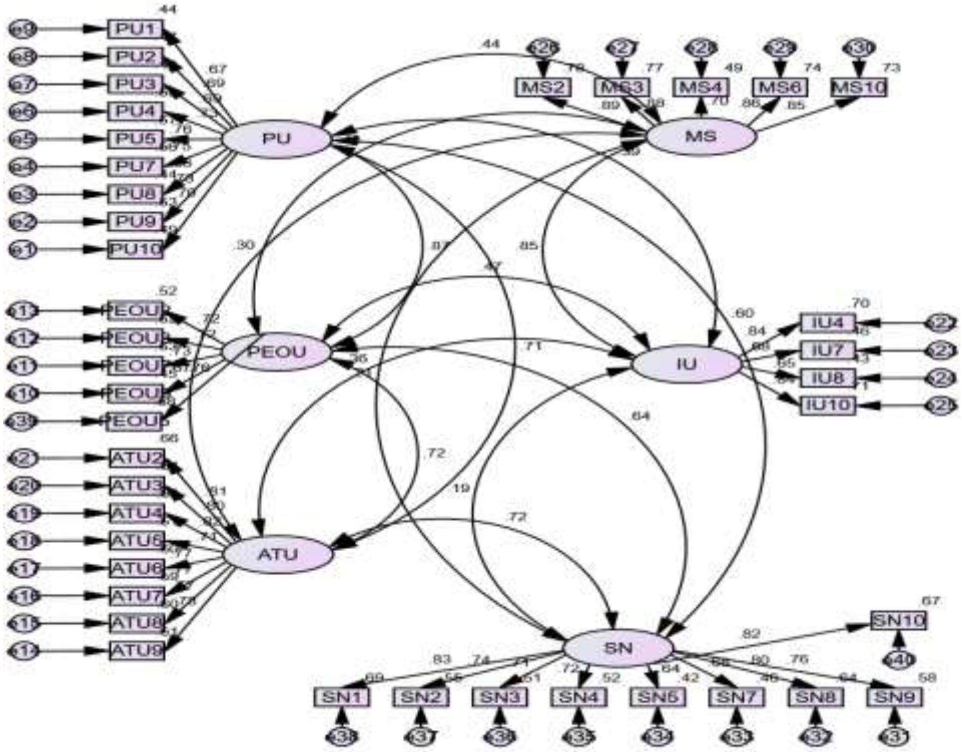

Figure 1- CFA Diagram

The diagram above is the Structural Equation Model (SEM) diagram which gives a schematic representation of the hypothesis of this study. The research model has six reflective constructs namely Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Attitude Toward Using (ATU), Intention to Use (IU), User Satisfaction (MS) and Subjective Norm (SN). The closeness of these relationships is evidenced by the factor loadings and path coefficients from the analysis that depicts the strength of one latent variable impacting its indicators as well as examining the impact of one latent variable on another. It also incorporates error terms corresponding to each of the observed variables thus the unexplained variations are also included in the model.

4. RESULTS

This table shows the total of the estimated paths of the structural equation model's conceptual diagram of the latent variables. In fact, it is shown by the present study that Covariances such as PU, PEOU, ATU, SN, IU, and MS are related significantly.

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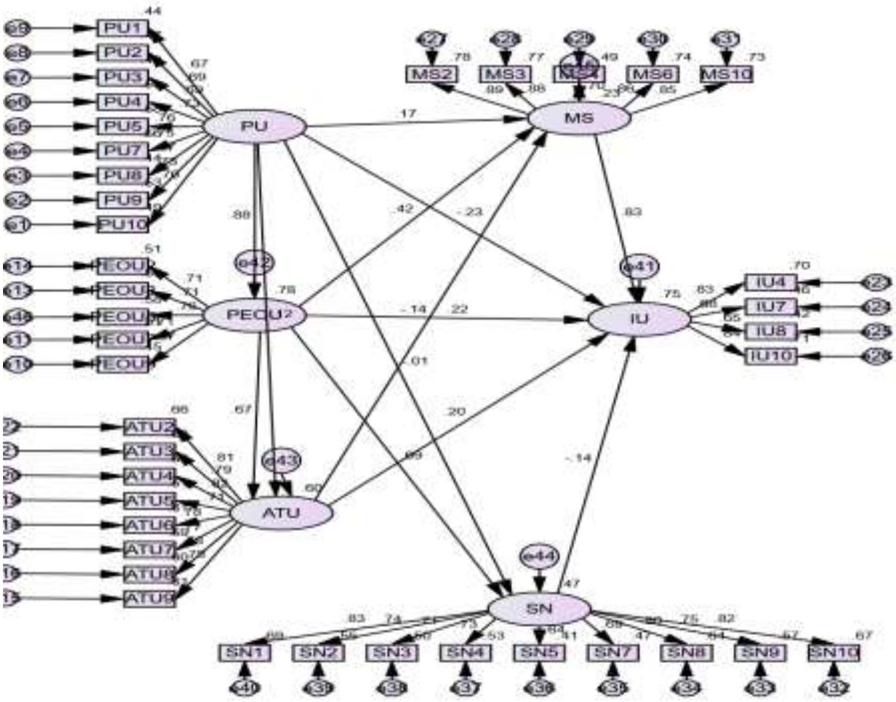
Figure 1 - Path Analysis



From the diagram above, PEOU has a very high path coefficient with PU, measured at 0.88., which suggests a strong influence. In analyzing variables that motivate a person's intention to use the system, it is noted that if the user believes the system is useful, then over time, the user will consider the system easy to use, this goes to support the first hypothesis.

Again, the findings of the analysis further elucidate the complex interrelationships among the determinants influencing the implementation of virtual reality (VR) within information and communication technology (ICT) education. Specifically, the perceived ease of use exhibited a consistently positive correlation with students' attitudes toward VR utilization as well as their intention to engage with this technology in the future which supports hypotheses 2 and 4. Additionally, a favorable attitude toward VR implies an elevated intention to utilize it which does support hypothesis 3. Furthermore, the anticipated positive impact of robust social norms on the intention to employ VR as an educational instrument is not emphasized within the present study; instead, it was found that heightened social norms correspondingly diminished students' inclination to embrace VR simulations. In a similar vein, the role of substantial motivational support is crucial in enhancing students' readiness to utilize VR in their educational endeavours, and as the system's ease of use increases, so too does the motivation to engage with the technology which supports both hypothesis 6 and 7.

5. DISCUSSION

The causal relationship between perceived usefulness, ease of use and learning outcome. However, one of the most important research results is the confirmation of the great interaction

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between two variables: Perceived Ease of Use (PEOU) and Perceived Usefulness (PU). This implies that the students' attitude towards VR in terms of ICT concept understanding will be informed by the ease of use of the technique. In particular, educators should be concerned with the simplicity of VR tools that would be applied in the classrooms since some of the learners may not have interacted with the technology before.

The teacher may add new features that expose the students to VR systems that give them exposure to actual systems like networks and software facilities. The specified set of simulations will prove valuable exactly in so far as they are made easily accessible to the students with the help of a simple Interface: in this case, the simulations will be appreciated by the students, and will thus help in a better understanding of the topic in question. The ease of use also helps to cut the workload on their brains and therefore they can spend more time and effort trying to understand whatever information is being imparted to them.

Additionally, promoting Attitudes towards and Self-Reported Intentions of VR Concerning students' attitudes towards the specific technology of VR, this research reveals that students' perception influences their intention toward the use of this technology in ICT education. A positive attitude towards VR is more inclined towards the use of VR in other learning activities in the future. To create such favourable perceptions, educators can always create awareness of how VR makes learning even more exciting, interactive, as well as productive. This can be done when the teachers use ICT and show how valuable these tools are in learning, such as using virtual labs and other related visual teaching methods or conducting immersive coding, students can understand their importance more effectively. Also, when students start using VR and get a positive first-time result aligned with the fact that they like that type of practice, they will be motivated to continuously use VR as part of their classes.

Surprisingly, the social norms' increase was not related with the intention to use VR. Sometimes, a high level of social pressure decreased students' readiness to interact with VR in general. Based on this finding it can be implied that although encouragement by peers and instructors is crucial, it should be done without overtones that may make learners avoid the examination of VR as a tool beyond what has been encouraged by their peer and instructors.

To practice this, teachers should provide the setting where the students can voluntarily use the VR but at the same time, there will be no pressure concerning its utilization. It may mean providing extra voluntary VR based lessons or proposing extra ways that can be utilized for those learners who may not feel quite comfortable with VR. In this way, teachers can develop a better atmosphere for studying from which cultural norms are less likely to hinder people's talents and choices while enforcing beneficial technologies for interactivity.

The paper emphasizes that motivational support appears to be decisive in helping the students use VR in their ICT learning. The more accessible the technology, the more motivating the technology is for the students. In view of this, motivative strategies can be incorporated into the methods that are used in teaching by educators. For example, they can establish learning games through the use of VR in which the learners have bonuses in exchange for achieving the specific objectives while operating in virtual space. It also increases the fun of learners, which in result increases the chances of them digging deeper into the content being taught.

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6. CONCLUSION

The data analysis undertaken in this research work offers valuable ideas on the use of Virtual Reality in ICT Education. The results also emphasized the outstanding importance of the impact of Perceived Ease of Use, PU, Attitude Toward Using, IU, MS, and SN regarding the experience and intention of the students to VR usage as a tool of learning.
These strong correlations identified between these factors develop a need for careful selection, training, and support to move the implementation of VR in educational settings. In an effort to maximize these educational benefits, it is of paramount importance that VR tools are user-friendly, there is sufficient training, and positive attitudes toward using the technology are fostered. Furthermore, the research unravels a fragile web of social norms intertwined with motivational factors that indicate encouragement from peers and tutors is helpful but has to be measured in dosage, lest the effect become too over-isolating for students.
It is true that this research stands on promising ground to enhance training in ICT, In essence, the results of this study give educators, curriculum designers, and policymakers significant guidelines that shall be helpful in integrating VR into ICT education. Thus, institutions will be able to utilize the learned lessons towards designing learning environments that are more stimulating, immersive, and effective in taking on the new and changing requirements of life in the digital era.

6.1.Practical Implication

The implication that can be deduced from the analysis of the collected data is as follows for using VR into ICT education. It means that the implications stated above can be helpful for educators, authors of curricula, and policy-makers to determine how and when it is possible to use VR tools in order to support teaching and learning activities.
Selection of User-Friendly VR Tools: When it comes to ICT education, the choice of efficient VR tools must remain comprehensible so that students can easily study certain material rather than be bound by operations.

Training and Support for Students: Students should receive ac-aademic support in VR technology, giving lectures, practical session, tutorials, and continuous support, in order to boost their awareness and confidence of VR technology.
Encouraging Positive Attitudes Towards VR: Perceived attitudes therefore have a positive effect on the intention of the student to use Virtual Reality in learning. Teachers need to build such contexts that would not cause students any discomfort, generalize on successful examples, and show the variety of applications of VR.

Limitations

Major obstacle to the successful implementation of VR in a learning environment was due to technological factors alongside the learning curve of the users and cost which should highly be a consideration when implementing the same in underprivileged areas.s.

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