Factors Affecting the Intention to Use Virtual Reality in Education

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ABSTRACT

Virtual Reality has become inevitable in this modern world as it is considered one of the developments that ICT has achieved. A variety of fields, including medicine, engineering, agriculture, training, education, etc. benefit from the elevated growth of Virtual Reality hardware and software technologies. The education field has started embracing this technology to increase the effectiveness of the teaching-learning process. The technology is effective, but at the same time, it contributes a lot to a greener world by eliminating the need for field visits, lab experiments that damage the environment, and avoiding the need for physical presence. While the development of Virtual Reality technology is predominant in the western countries, accepting and coming forward to use the same in India is comparatively slower. Several factors contribute to the successful use of any ICT tools in a classroom, among which the teacher's readiness to learn and implement technology is crucial. This study focuses on the teacher-related factors that affect the intention to use Virtual Reality in their classrooms. Using the Technology Acceptance Model, 92 teachers handling different subjects from high schools in Tamil Nadu, India, who volunteered were included in this study and accessed. Teachers were given a questionnaire after the intervention of VR applications. The study concludes that the Virtual Reality hardware, software applications must be easy to use, readily available content for the taught subject, and the awareness of the pros and cons would drive the teachers' intention to use Virtual Reality. This study's outcome also provides practical implications of using Virtual Reality in the classrooms with shreds of evidence from the literature.

Keywords
Virtual Reality in education, VR in education, TAM, Technology Acceptance Model, VR in Classroom, Teaching aid.

Article Received: 10 August 2020, Revised: 25 October 2020, Accepted: 18 November 2020

Introduction

Building a simulated reality with computers' help, visualizing the built reality through special hardware and software is defined as virtual reality (Rogers, 2019). Interactive 3D virtual reality-based education has become one of the inevitable technologies in today's education system. This VR technology enables us to create realistic virtual environments and allows us to immerse ourselves in the environment and interact with the elements in it. According to research, virtual reality is considered very effective because it easily helps transfer the learned skills to the real world from a virtual world (Krokos et al., 2019). This technology is widely used to train pupils in areas where accessing the real world is impossible or expensive (Zhang, 2017). For example, it is impossible to observe a flight by floating in the sky, and at the same time, it would cost a lot to schedule a submarine drive under the seas. The impossible becomes possible with virtual worlds, and expensive becomes inexpensive, thus enabling educators to step out of the traditional teaching methods that reap expected outcomes. Despite the advantages of VR technology, implementation is not so predominantly found in Indian schools. There are so many factors that contribute to the use of VR in classrooms. Some of the applications and hardware are costly, thus difficult to adopt, but cost-effective alternates could be used (Díaz et al., 2019). Educators' intention to adopt new technology has always been a challenge and considered as a critical issue. This piece of research work aims to study the intention of educators to use VR in their classrooms.

Across the globe, several studies have focused on teachers' perceptions towards the use of virtual reality technologies in their classroom (Abd Majid & Mohd Shamsudin, 2019; Dong, 2016; Han et al., 2017; Peng, 2019). Still, there is a need to conduct similar studies in a localized context to understand the teachers' perceptions as the results could vary according to the context and specific aims. This research paper is organized swiftly, and the content includes the following: hypothesis in the form of research questions in section 2, the literature review relevant to the chosen topic in section 3, an explanation on the methods of this study in section 4, discussion on the observations in section 5, limitations of this study and scope for future research in section 6 and finally the conclusion in section 7.

Research Questions

1. Will the intention to use VR, gets influenced by perceived usefulness?
2. Will the intention to use VR, gets influenced by perceived ease of use?
3. Will the acceptance level change based on the application used and subjects taugt?

Literature Review

Virtual Reality has enormously contributed to education; it is a unique way of reaching out to the students and a tool that enhances the students' motivation by fostering hands-on learning (Brewer et al., 2015). From kindergarten to research studies, VR can be used to enhance learning by providing suitable applications to cater to the need of the time. Immersion is a key factor in VR as it isolates the user from the external world and suspends the belief of entering the virtual world.

3.1. VR Hardware

VR hardware is available with different features & price. More features like haptic feedback, eye tracking, etc., are added, the cost of the device increases (Coburn, 2017). Depending on the feasibility of the institute or educator to afford the hardware/software for VR and the type of application to be used, any one of the following categories of Head Mounted Displays (HMDs) can be chosen:

- Slide-on –HMD
- Discrete HMD
- Integrated HMD

Table 1 juxtaposes the categories of HMDs, popular models under each category, its features, and the average cost.

Google Cardboard is one of the famous, most cost-effective HMD under the slide-on category. Figure 1 shows a kid experiencing VR with one of the models of Google Cardboard at Cyber-Physica Systems (CPS) lab at VIT, Vellore, India. Oculus Rift is the famous model under the discrete HMD category, which is the roadmap for high-end VR content delivery. Figure 2 shows VR content being tested at the VR lab at VIT, Vellore, India. Google Glass is available for enterprises to work on and try their projects. It is very much handy and is mainly meant for Augmented Reality (Figure 3).

Figure 1. Google Cardboard

Figure 2. Oculus Rift

Figure 3. Google Glass

Table 1. Analysis of different categories of Head Mounted Displays (HMDs)

Category	Model	Features	Cost (USD)
Slide-on-HMD	Google Cardboard	✓ Simple & easy to use ✓ Cheapest of all HMDs ✓ Works with most of the smartphones ✓ Simple actions are possible	7$
	Samsung Gear VR	✓ Easy to use ✓ Includes natural, one-handed controller ✓ Works only with specific Samsung smartphones	110$
Discrete HMD	Oculus Rift	✓ In-built display ✓ Includes two powerful controllers ✓ Highly comfortable	900$
	HTC Vive	✓ Easy to use ✓ Hand-held controllers ✓ OLED display	850$
Integrated HMD	Google Glass	✓ In-built camera ✓ Prism Projector ✓ WiFi connectivity	1600$
	Microsoft Hololens	✓ Only the developer version is available ✓ First HMD that runs Windows Mixed Reality OS ✓ Widescreen HMD	3200$

3.2. VR Software

As far as the VR software is concerned, there are plenty of options available to choose. An organization can decide to build its VR content to align with their syllabus or reach out to appropriate VR content developers/development companies and procure existing content. They may even opt to download free content that is available on the internet via Google Play or App Store. In addition to these options, there are simple VR development solutions that allow educators or students to create custom made content. For example, CoSpaces Edu is one such simple authoring tool that allows teachers or students to create interactive VR environments without programming expertise. It uses a simple visual programming structure called blocks, as shown in Figure 4, that enables a novice user to create stunning interactive VR applications. This type of tool is hype for educators from the non-IT background and students who start their VR journey. The advantage of this online VR collaborative tool is that it can be accessed even from mobile phones, tablets, and Chromebook.

Among several VR tools available, one of the most promising tools that allow teacher-student collaboration is CoSpaces Edu (Frydenberg & Andone, 2019). It is effortless and easy to use, thus enabling the teachers as well the students to explore. VR scenes can be created effortlessly, programmed, and shared with the gallery, which can be viewed on a mobile device with the help of Google cardboard. For teachers who seek a collaborative VR environment, CoSpaces is a must-try online tool that doesn't occupy any space in the local hard drive.

Much advanced software is also available for professional VR contentment development, but that is not the teachers' cup of tea. It is always a good practice to explore mobile apps that are relevant to the taught subject until the institution procures some subscription models or standalone software to use.

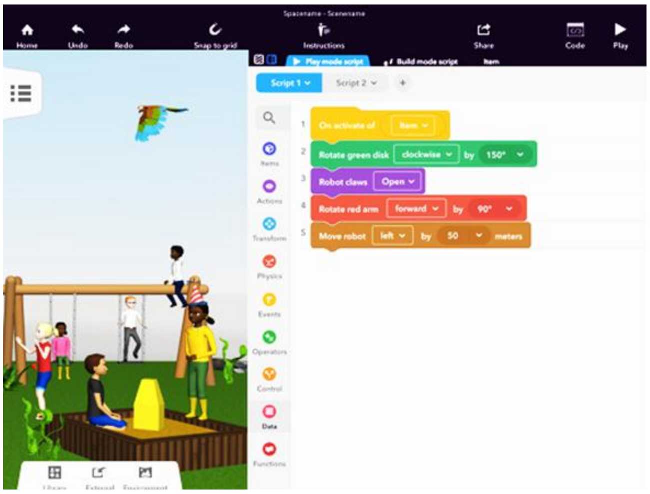

Figure 4. Interface of CoSpaces web application

3.2. VR and TAM

Since the educators' usage intention is evaluated in this study, relevant studies were examined to elucidate relevant research findings. For this research, articles from the Scopus database are explored by restricting the query string as given below, which resulted in 18 documents.

(TITLE-ABS-KEY ("virtual reality" AND tam) AND NOT TITLE-ABS-KEY ("medical" OR "industry")) AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016)) AND (LIMIT-TO (SRCTYPE , "j") OR LIMIT-TO (SRCTYPE , "p")) AND (LIMIT-TO (LANGUAGE , "English"))

Obtained results (n=18) from different subject areas as shown in Figure 5 were taken into initial consideration and filtered based on the relevance of the topic relativity to TAM which resulted in 8 articles.

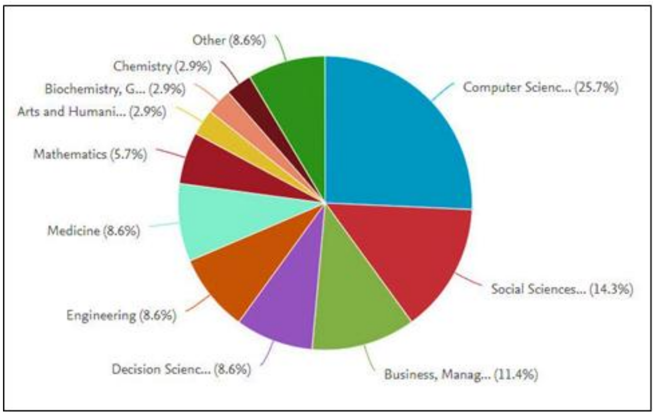

Figure 5. Documents by subject area (n=18)

A similar study was conducted with 98 respondents from Malaysia, which suggests that perceived usefulness is a construct that directly affects the intention to use VR in the classroom (Sagnier et al., 2020). Another study implies that users' satisfaction with the VR application contributes to the intention to use VR (Rhee, 2019). Teachers get motivated when the students show interest in the methodologies adopted in the classrooms, students tend to use VR if the application is easy to use, the same is useful for that particular context and when they are motivated (Huang & Liaw, 2018). Such evaluations may not always be considered a general indicator because the obtained results could be due to the user's situation or situated goals (Triberti et al., 2016). A research carried out during 2015 with older adults reveals that the users found the computerized 3D design application as a useful tool but certain aspects of the tool have to be modified to suit the age group (Money et al., 2015). The other study emphasizes that instead of regular narrations, using different media usage types in the classroom will enhance the learning outcomes (Richter et al., 2016). Before setting up a virtual laboratory, students' intention was tested in a study that revealed all TAM constructs contributed to the students' intention to use the proposed VR lab (Sommool et al., 2015). Motivation to learn new technologies is another factor that affects a technology's perceived usefulness (Huang & Liaw, 2018).
The benefits of using VR is being emphasized in several studies. (Pivec & Kronberger, 2016) states that non-physical tours could be organized with the help of virtual tours by which we contribute a greener environment by avoiding travel and at the same time save a lot of money. Using VR in the classrooms has proved to be more promising than the conventional methods of teaching.

Methodology

Literature was reviewed to analyze similar studies that analyze the deployability of VR from the users' perspective. Any innovation in the technology can be accessed easily for its acceptance among users with the powerful model called the Technology Acceptance Model (TAM), which researchers widely recognize (Abd Majid & Mohd Shamsudin, 2019). TAM is a useful model that helps determine users' attitudes and intentions to use new technology (Silva, 2015). This model is formulated using some of the constructs defined in Table 2. This study focuses on the four constructs of TAM, namely, Perceived Usefulness (PU), Perceived Ease of Use (PEoU), Usage Attitude (UA), Intention to Use (ItU), and research framework was formulated with these constructs. The relationship between the four constructs is depicted in the research framework as highlighted in Figure 6.

Table 2. Constructs of TAM

Construct	Meaning	Reference
Perceived Usefulness (PU)	To what extent the system will enhance the user's job performance	(Triberti et al., 2016)
Perceived Ease of Use (PEoU)	The degree of feeling that makes the user believe that the technology doesn't require any physical or mental efforts	
Usage attitude (UA)	A feeling that motivates as good to go	
Intention to use (ItU)	A construct that pushes the user to do a specific behavior.	

For this study, data was collected and examined based on the grounded theory approach. A questionnaire was formed and distributed to teachers from 12 different schools in a chosen district of Tamilnadu, India. Initially, they were introduced to VR applications related to their subjects and also were asked to explore the web-based VR development platform called Co-Spaces. Teachers' interest in using VR technology to teach their subject and their opinion to use this technology was recorded and summarized.

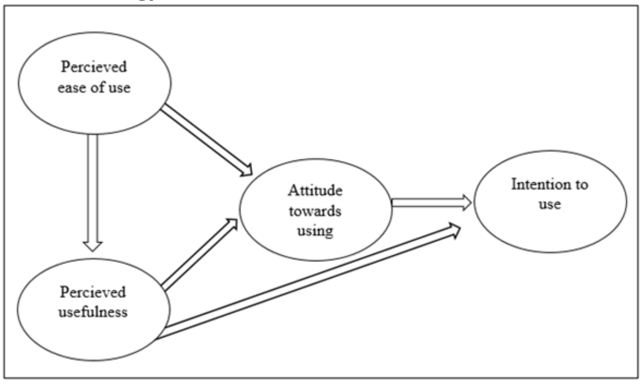

Figure 6. Relationship of constructs: Research Framework

The questionnaire was formulated based on the validated constructs according to TAM (Triberti et al., 2016), and slightly modified in simple English to suit the context of this study. Answers for the questions were obtained in the form of a 5-point Likert scale, as shown in Table 3.

Table 3. 5-point Likert scale

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

A set of four questions were clustered under each of the four constructs of TAM as follows:
Perceived Usefulness
Q1. VR applications help me to enhance the teaching pedagogy.
Q2. Using VR applications in my class enhances overall teaching performance.
Q3. VR is useful for my subject.
Q4. Using VR applications enables me to grab students' attention.

Perceived Ease of Use
Q5. VR applications are easy to use.
Q6. It is easy to apply VR concepts for my subject.
Q7. Using VR applications is easy to understand.
Q8. VR offers more flexibility than traditional teaching.
Attitude Toward Using
Q9. Using VR applications in class is good.
Q10. Using VR in the classroom creates a positive influence.
Q11. It is a value-addition to use VR in my classroom.
Q12. I that using VR in the classroom is a current trend.
Intention to Use
Q13. I tend to use VR applications in my class.
Q14. I increase the occurrences of using VR materials in my classes.
Q15. I use VR to facilitate teaching with multiple approaches.
Q16. I use VR to attract the attention of students towards learning.

For this study, a group of 92 teachers with different specializations from 12 different high schools were selected. Their subject areas are tabulated (Table 4), and their opinions on using virtual reality technologies were obtained after they tried VR applications in their classrooms.

Table 4. Participant details

No	Subject	Number of Teachers	Male	Female
1	Tamil	14	6	8
2	English	16	9	7
3	Maths	21	14	7
4	Science	18	7	11
5	Social Science	11	6	5
6	Computer Science	12	7	5
	TOTAL	92	49	43

Since it was observed that many of the participants were not aware of the technology, few existing VR applications were chosen based on their subject specialization, and they were allowed to use them before using it their classes. Basic training on how to use the application and operate Google Cardboard was given. A step by step tutorial on how to make use of the features of Co-Spaces was given to make them create and share their VR content if required or use the existing content from the gallery. The gallery in co-spaces is available under the categories, namely stem & coding, social science, language & literature, and marketspaces & arts. Chosen applications and the corresponding subject category are listed below:
Tamil: Created using Co-Spaces (https://cospaces.io/edu/)
Since there are no free VR resources available to teach the Tamil language, it is decided to remix an existing Cospaces project to get the desired output.
English: VR Learn English from Google Play (https://play.google.com/store/apps/details?id=com.vr.learn_english&hl=en)
Maths: VR Math from Google Play (https://play.google.com/store/apps/details?id=com.vrmath&hl=en_IN)
Science: Bacteria interactive educational VR 3D and Human body (male) educational VR 3D from Google Play (https://play.google.com/store/apps/details?id=com.rendernet.humanmale&hl=en_IN)
Social Science: Sites in VR and Acropolis Interactive educational VR 3D from Google Play (https://play.google.com/store/apps/details?id=com.rendernet.acropolis&hl=en_IN)
Computer Science: What's inside a computer from Co-Spaces gallery (https://edu.cospaces.io/DPA-ZAU)

Discussion

When it comes to introducing new technology, technology's success or failure depends on the users' acceptance ratio. The user acceptance of new technology is considered an essential factor that determines the success or failure of technology (Mones, 2017). While mixed opinions prevailed among different subject teachers, most of them agreed that VR could benefit them in enhancing the teaching process. Since this study was analyzed based on TAM, tests were conducted to validate the questionnaire used. Summary of the result analysis shows that there are no missing data in the obtained answers; the reported standard deviation values of PU, PEoU, UA, and ItU stand between 0.856 and 0.954, which represents the closeness to the expected value as summarized in Table 5.

Table 5. Summary of observation

Variable	Obs	Obs. with missing data	Obs. without missing data	Min	Max	Mean	Std. deviation
PU	92	0	92	2	5	3.717	0.856
PEoU	92	0	92	1	5	2.891	0.895
UA	92	0	92	2	5	3.109	0.883
ItU	92	0	92	1	5	3.033	0.954

Pearson's correlation matrix was used to establish the connection between the constructs. Table 6 highlights each construct's values against the other three constructs; the bold values are different from 0 with a significance level alpha=0.05, indicating the relationship's significance. According to the results, there is a noticeable influence of each construct against the others while PEoU and UA resulted in a lower value, which shows that the perceived usefulness has an impact on perceived ease of use, which in turn results in usage attitude and intention to use. Similarly, Intention to use is affected by the perceived usefulness and ease of use, which has also contributed to the usage attitude and intention to use. User attitude (UA) is dependent on the perceived usefulness and perceived ease of use. In this result, the correlation between UA and PEoU is identified as a low value, but still, the intention to use (ItU) remains almost on the same slab as PEoU. The same data is interpreted in the form of a correlation map in Figure 7.

Table 6. Correlation matrix (Pearson)

Variables	PU	PEoU	UA	ItU
PU	**1**	**0.261**	**0.230**	**0.334**
PEoU	**0.261**	**1**	0.099	**0.210**
UA	**0.230**	0.099	**1**	**0.217**
ItU	**0.334**	**0.210**	**0.217**	**1**

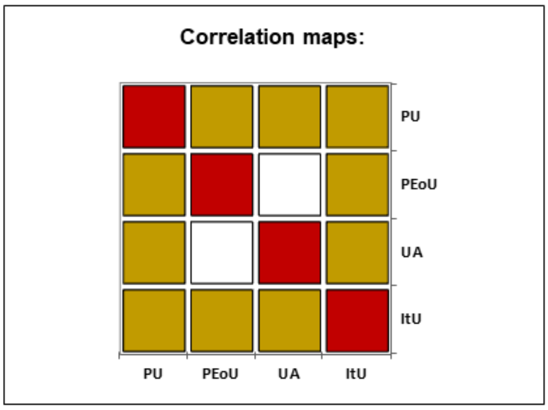

Figure 7. Correlation map of each construct

Research (Huang & Liaw, 2018) states that Cronbach's alpha value greater than 0.7 is considered an acceptable value; this study reported the least value of 0.73 and the highest value of 0.91, considered acceptable values confirming the internal reliability as shown in Figure 8.

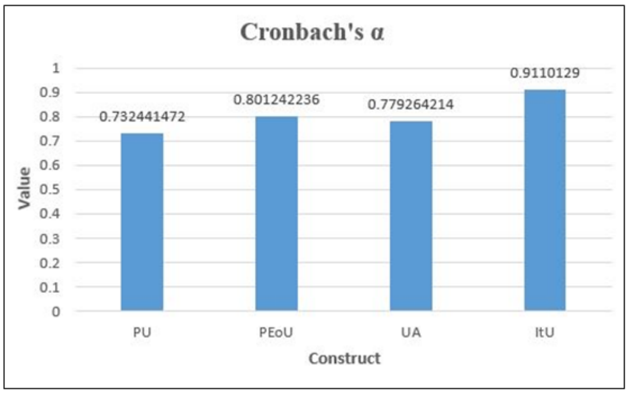

Figure 8. Cronbach's α of each construct

The gender-based analysis of the results showed that female teachers reportedly show much interest in using VR in the classroom compared to that of male teachers. It was observed that in mathematics and English subjects, the interests of male teachers were slightly higher. Mathematics teachers reported the lowest 21.4% interest while the highest was 41.3% for science subject female teachers. Figure 9 summarizes the gender-based report of readiness of teachers for each subject.

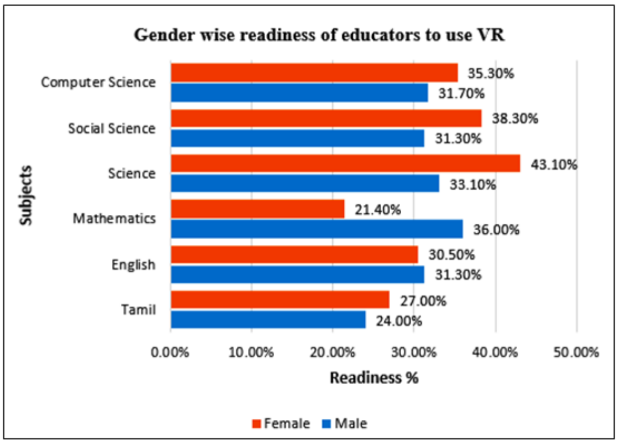

Figure 9. Gender-based analysis

Summing up all the observed values, it is evident that the educators are ready to use VR applications in their classrooms, and their level of interest varies from one subject to the other, as illustrated in Figure 10. This study shows that science teachers' readiness is more predominant while that follows social Science, Computer science, English, Mathematics, and Tamil. A difference of 25.2% was noted between the highest and lowest level of readiness. The reason for this could be the availability of resources. Most of the standardized contents cost a lot, and many of the time, they are not available for testing the full features. HMDs are moderately immersive compared to that of a CAVE – Cave Automatic Virtual Environment (Bakr et al., 2018). These results might have a slight deviation if appropriate applications that are aligned with the syllabus are procured and distributed. Tamil is a native language of Tamilnadu, South India, lacks or almost no VR-based applications. The reason could be because of fewer commercialization chances since the market is not widespread like the English language. The standard deviation for the calculation for the subject wise readiness is less than 1.

Standard Deviation, s: **8.9799777282575**

Count, N:	6
Sum, Σx:	384
Mean, $\bar{x}$:	64
Variance, s^2:	80.64

Steps

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2},$$

$$s^2 = \frac{\Sigma(x_i - \bar{x})^2}{N - 1}$$

$$= \frac{(67 - 64)^2 + ... + (51.00 - 64)^2}{6 - 1}$$

$$= \frac{403.2}{5}$$

$$= 80.64$$

$$s = \sqrt{80.64}$$

$$= 8.9799777282575$$

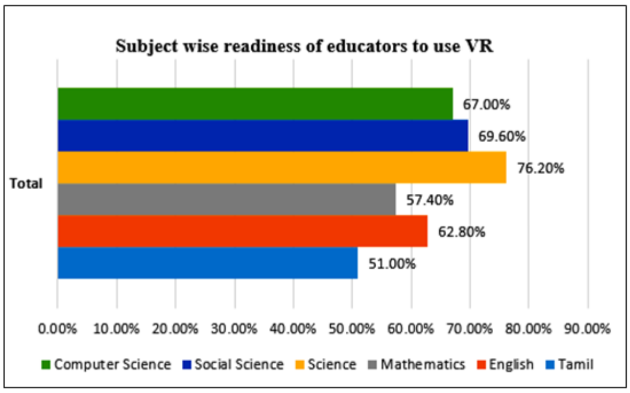

Figure 10. Subject-based analysis

To effectively manage a classroom, several factors are to be considered, among which usage of teaching materials is regarded as the most important as it engages the students (Kubat & Dedebali, 2018). In some courses, field trips to factories or the industries play an essential role in conveying the taught concepts effectively (Netland et al., 2020). VR is mostly sought after by the teachers who already have been using ICT tools to support their teaching. On that note, the subjectwise readiness analysis of this study shows that the following subject teachers are ready to use VR (sorted in ascending order: 1 being the highest)

1. Science
2. Social Science
3. Computer Science
4. English
5. Mathematics
6. Tamil

The discussion below highlights the answers to the formulated research questions, which are derived from the mathematical analysis of the received responses:

Will the intention to use VR, gets influenced by perceived usefulness?

Yes, the perceived usefulness of technology has a significant impact on the intention to use VR. Firstly, the teachers should believe that VR technologies are a boom to their academic activities but not an extra burden. Wide chances are there for the teachers to be drifted away using this technology because of many misleading factors. It is essential to conduct sessions/workshops that portray the uses of VR technologies to eliminate such problems. Simultaneously, the negatives of the technology, and the ways to eradicate or avoid them should also be briefed in detail.

Will the intention to use VR, gets influenced by perceived ease of use?

Yes, the intention to use VR gets influenced by the perceived ease of use of the technology. The analysis shows that not all teachers are familiar with the latest ICT tools. To try different VR tools to be used in their classrooms, the devices, software tools, and elements must be user-friendly and must not force the teachers to undergo any intense training. It is as simple as how the whole world got adopted to use advanced gadgets without training. In general terms, more straightforward the interface, procedure, and integration of VR in regular classes, there will be sturdy intentions towards using the technology.

Will the acceptance level change based on the application used and subjects taught?

Yes, there is a significant difference in the responses when the taught subject is different among the teachers. Language and mathematics teachers feel that they will not be benefited much from VR technologies. Lack of information on the precise use of this technology for specific subjects also leads to varying acceptance rates. On the other hand, it is also dependant on whether the teachers already use any other ICT technologies in their current practice. A video blog improves student performance by reducing anxiety while speaking in public (Madzlan et al., 2020). Likewise, there are plenty of research outputs available for the use of VR in language education, highlighting this technology's support in enhancing learners' skill (Alfadil, 2020; Xiao-Dong & Hong-Hui, 2020).

Limitations and Scope

This study carried out on a smaller scale with 92 participants may not have yielded results that could be equivalent to the larger experiments, but it is still an ideal sample for the initial study. When the perceived ease of use increases, the intention to use will also increase. So, if custom made VR applications are procured and used, the resultant percentage will increase for all the constructs. For this study, developing such a tailor-made application is out of scope. Limitations of VR that cause a setback from intention to use are not discussed in this study, and it is kept aside for future enhancement. Future developments could include localized, easy to use VR content that is aligned with the taught syllabus or procure a content relevant VR application. This topic, VR in education, offers a wide scope to explore, which would be carried out in the future.

Conclusion

To effectively implement VR in classrooms, the attitude of educators plays an important role. This positive attitude can be achieved if the educators have the right perceptions of VR and its usefulness. It is suggested to initially expose the stakeholders to the uses of VR and its educational implications. There are many VR resources available to use in the classroom, but appropriate training pieces should be organized to show how to integrate VR into teaching activity. When the educators feel and understand VR's usefulness in the classroom, their attitude to using and intention towards usage will change. Top-level management and Government officials should support such initiative by purchasing affordable hardware and subscribe to software content relevant to the courses offered. It will be a great initiative if the VR hardware and software vendors come forward to sponsor a few institutions to conduct research studies. It’s high time that all the stakeholders think about the positives associated with implementing VR in classrooms to empower schools

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