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Virtual Reality in Education: Educators Perspective of Accepting the Technology based on TAM

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ABSTRACT--*One of the most promising technologies in this fast-changing world is Virtual Reality. It is expected that virtual reality technologies will become an inevitable part of education and training needs. While the term virtual reality is very commonly used for gaming, it is also evident that this technology has contributed a lot, simplified many tedious learning processes. Education is getting a new dimension with the help of virtual worlds, the realistic simulations, and the immersion offered by virtual reality applications. Especially, complex and abstract concepts can be explained easily with lesser efforts as well as expenditure, but at the same time, due to its limitations, still there exist some mixed opinions on this technology. The readiness of teachers is one of the important factors that contribute to the implementation of this technology in classrooms. This study was carried out with a population of 92 educators from southern India, and the Technology Acceptance Model (TAM) was used as an aid in determining the acceptance level of the participants. The results showed that the ease of use of VR applications, its availability, and awareness of the usage would enhance the intention to use.*

Keywords*— Virtual Reality in education, VR in education, VR review, TAM, Technology acceptance model*

I. INTRODUCTION

Building a simulated reality with the help of computers, visualizing the built reality through special hardware, and software is defined as virtual reality (Schunk, 2012). Interactive 3D virtual reality-based education has become one of the most inevitable technologies in today's education system. This technology not only enables us to create realistic virtual environments but also allows us to immerse ourselves in the environment and interact with the elements in it. According to research, virtual reality is considered to be very effective because it is easy to transfer the learned skills to the real world from a virtual world (Earnshaw, 2014). This technology is widely used to train pupils in areas where accessing the real world is impossible or expensive (Freina & Ott, 2015). For example, it is impossible to observe a flight by floating in the sky and at the same time, it is very expensive to schedule a submarine drive under the seas. With virtual worlds, impossible becomes possible, and expensive becomes inexpensive thus enabling the educators to step ahead from the traditional methods of teaching that reaps standard 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 still, there are cost-effective alternates that could be used (Díaz et al., 2019). Educators' intention to adopt new technology has always been a challenge and considered as a critical issue. The purpose of this paper is to study the intention of educators to use VR in their classrooms.

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II. RESEARCH QUESTIONS

1. Will the intention to use VR gets influenced by perceived usefulness? (RQ1)
2. Will the intention to use VR gets influenced by perceived ease of use? (RQ2)
3. Will the acceptance level change based on the application used and subjects taught? (RQ3)

III. VR IN EDUCATION

Virtual Reality has enormously contributed to the field of education, it is a unique way of reaching out to the students and a tool that enhances the motivation of the students by fostering hands-on learning (Brewer et al., 2015). From kindergarten to research studies, VR can be used to enhance the process of 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 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 popular, 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 popular 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 test 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 developer version available ✓ First HMD that runs Windows Mixed Reality OS ✓ Widescreen HMD	3200$

3.2. VR Software

As far as the software is concerned, there are plenty of options available to choose from. An organization can decide on to build its VR content to align with their syllabus or reach out to appropriate VR content developers/development companies and procure existing content or 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 the need for expertise in programming. It uses a simple visual programming structure called as 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 who are from the non-IT background and also for students who start their VR journey. The advantage of this online tool is that it can be accessed even from mobile phones, tablets, and Chromebook.

Figure 4. Interface of CoSpaces web application

IV. LITERATURE REVIEW

Since the usage intention of the educators is evaluated in this study, relevant studies were examined to elucidate the findings of relevant researches. 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.

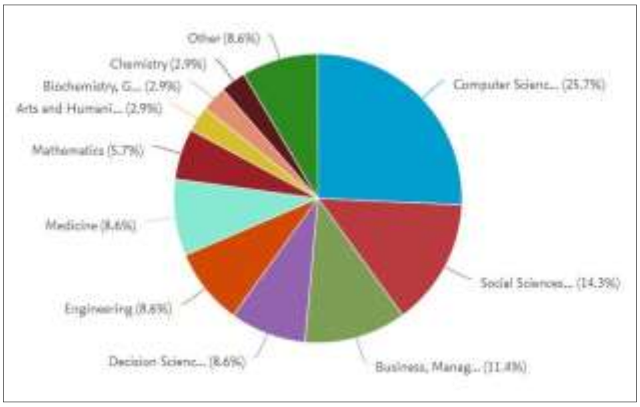

Figure 5. Documents by subject area (n=18)

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 be always be considered as a general indicator because the obtained results could be due to the situation of the user 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 types of media usage in the classroom will enhance the learning outcomes (Richter et al., 2016). To facilitate the virtual laboratory, students' intention was tested in a study that revealed all the constructs of TAM 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 the perceived usefulness of a technology (Huang & Liaw, 2018).

V. 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 the users with the help of the Technology Acceptance Model (TAM) which is widely recognized by researchers (Abd Majid & Mohd Shamsudin, 2019). TAM is one of the useful models that helps in determining the users' attitude and intention 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 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	(Davis, 1989)
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 construct that is influenced by external factors and/or other constructs	
Intention to use (ItU)	A construct that is influenced by external factors and/or other constructs	

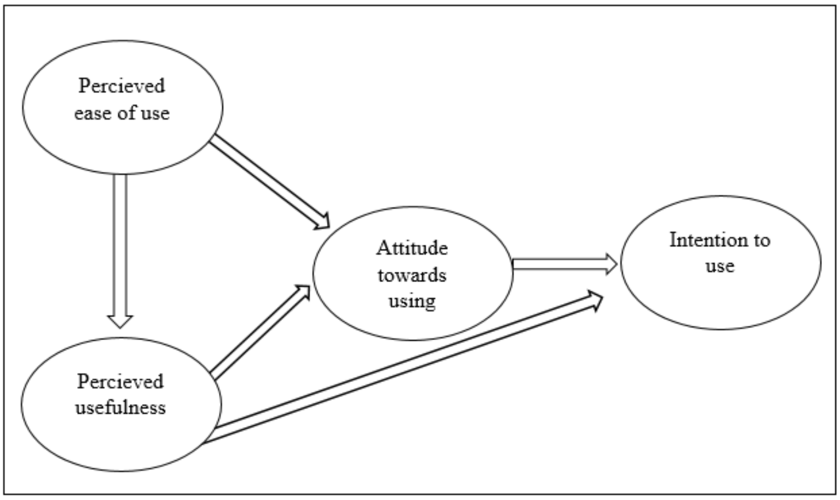

Figure 6. Relationship of constructs: Research Framework

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 before which 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. The interest of teachers to use VR technology to teach their subject, their opinion to use this technology was recorded and summarized.

The questionnaire was formulated based on the validated constructs according to TAM (Davis, 1989), and slightly modified 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 opinion to use 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 which is available under the categories namely stem & coding, social science, language & literature, and marketspaces & arts (*CoSpaces Edu :: Gallery*, n.d.). Chosen applications and the corresponding subject category are listed below:

Tamil: Created using Co-Spaces

English: VR Learn English from Google Play

Maths: Math VR from Google Play

Science: Bacteria interactive educational VR 3D and Human body (male) educational VR 3D from Google Play

Social Science: Sites in VR and Acropolis Interactive educational VR 3D from Google Play

Computer **Science:** What's inside a computer from Co-Spaces gallery

VI. DISCUSSION

One of the most essential factors that determine the success or failure of technology is the acceptance ratio of the users. The user acceptance of new technology is considered an essential factor that determines the success or failure of technology (Brevik, 2005). 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

Pearson's correlation matrix was used to establish the connection between the constructs. Table 6 highlights the values of each construct against the other three constructs, the values in bold are different from 0 with a significance level alpha=0.05 which indicates the significance of the relationship. According to the results, there is a

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

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 perceived ease of use which also has 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**

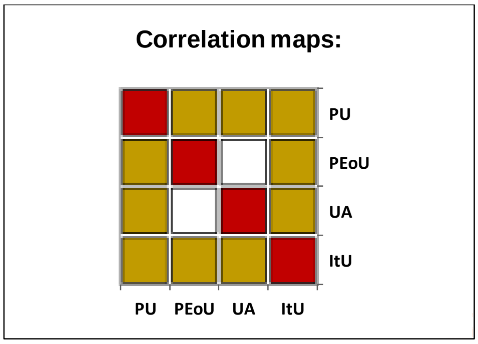

Figure 7. Correlation map of each construct

Research (Tavakol & Dennick, 2011) states that Cronbach's alpha value greater than 0.7 is considered to be an acceptable value, this study reported the least value of 0.73 and the highest value of 0.91 which is considered as acceptable values thus confirming the internal reliability as shown in Figure 8.

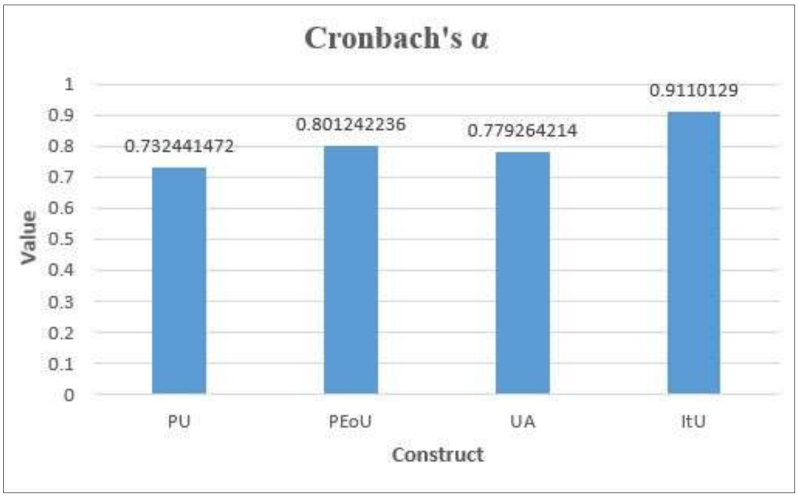

Figure 8. Cronbach's α of each construct

The gender-based analysis of the results showed that female teachers reportedly shows much interest of 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 of 21.4% interest while the highest being 41.3% for science subject female teachers. Figure 9 summarizes the gender-based report of readiness of teachers for each subject.

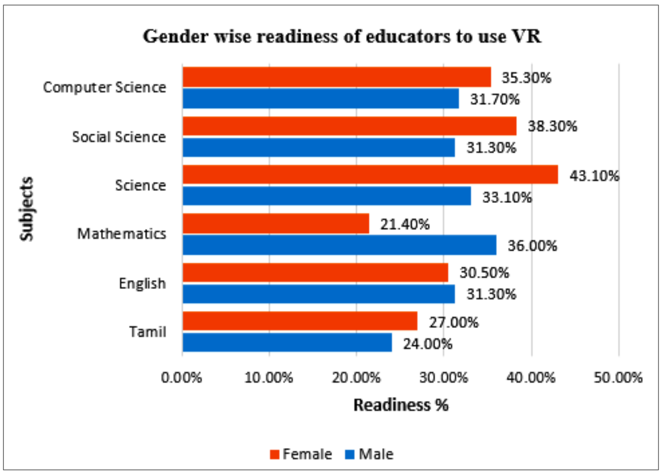

Figure 9. Gender-based analysis

Combining 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 the readiness of Science teachers are more predominant while Social Science, Computer science, English, Mathematics, and Tamil are followed by that. 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 (Häfner et al., 2013). 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 there are no VR based applications. The reason could be because of fewer commercialization chances since the market is not widespread like the English language.

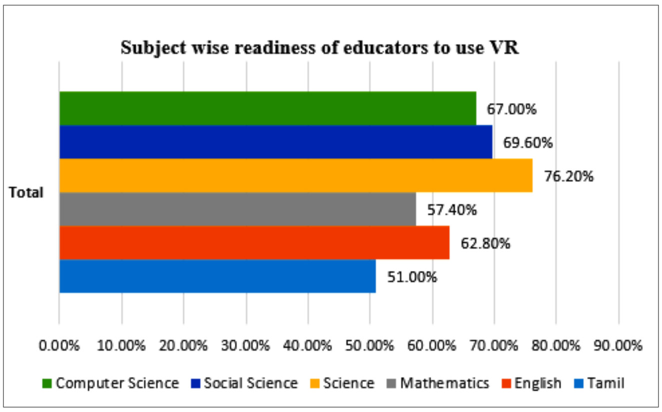

Figure 10. Subject-based analysis

VII. 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 still, it is an ideal sample for 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. There is a wide scope to explore this topic which would be carried out in the future.

VIII. CONCLUSION

To effectively implement VR in classrooms, the attitude of educators plays an important role. This positive attitude can be achieved only 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 pieces of training should be organized to show the ways of integrating VR into teaching activity. When the educators feel and understand the usefulness of VR in the classroom, their attitude to using, 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.

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