sdmimd
JOURNAL OF MANAGEMENT

DOI:10.18311/sdmimd/2025/50220

Awareness and Impact of Metaverse and E-learning Among Engineering Students, Tamilnadu

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Abstract

Metaverse is a common, immersive virtual environment in which people interact *via* avatars, integrating Virtual Reality (VR), Augmented Reality (AR), and web platforms. Metaverse in e-learning offers immersive, interactive experiences that enhance student engagement and learning. This research examines the influence of the Metaverse and e-learning on Engineering students in Tamil Nadu in terms of their awareness, attitudes, and the use of Virtual Reality (VR)-based learning environments. This study adopts a robust methodological approach involving descriptive research with a sample of 183 students from engineering colleges using convenience sampling. The implications of the study indicate the student's ability to increase interactive and learning outcome about Metaverse. However, several challenges block its effective adoption, including infrastructure constraints, less institutional support, and lack of access to appropriate devices. The results emphasize the necessity of enhanced infrastructure, ease of use interfaces and extensive training to enable the adoption of Metaverse. This study offers practical recommendations for educators and institutions to implement immersive technologies by creating innovative and interactive learning environments for engineering education.

Keywords: E-learning, Engineering Education, Metaverse, Technology Adoption, Virtual reality (VR)

1. Introduction

Sudden growth in technology has changed the way education is done, with the Metaverse, or a virtual environment combining virtual reality, augmented reality, and the internet, emerging as an effective trend. Interactive experiences are available on this platform, enriching learning in engineering, for instance, where intricate problem-solving and practical implementation is essential. Abstract concepts are translated into reality in virtual labs and simulations within the Metaverse, promoting collaboration and better understanding. Concurrently, e-learning offers flexible and accessible education through multimedia and online courses, adapting to various learning styles and accommodating engineering students' hectic schedules. This study aimed to examine the effect of the Metaverse and their influence on student engagement, academic achievement, and practical skills.

2. Review of Literature

Investigating the adoption of Metaverse in education is the focus for many scholars and practitioners globally and several studies were conducted to examine Metaverse's educational usages, highlighting greater engagement and access. However, some researches recognized challenges in adopting Metaverse such as privacy, inclusivity, ethical and infrastructural preparedness along with governance and it is essential to implement it successfully in education sector (Lin *et al*., 2022). Several studies were conducted to identify the important predictors of Metaverse adoption including future learning intention, technology trust, and anticipated benefits which determined perceived usefulness and ease of use among students (Rosli & Saleh, 2023). In Omani higher education, Metaverse adoption is influenced in terms of enjoyment, innovativeness, and complexity whereby, innovativeness was found to

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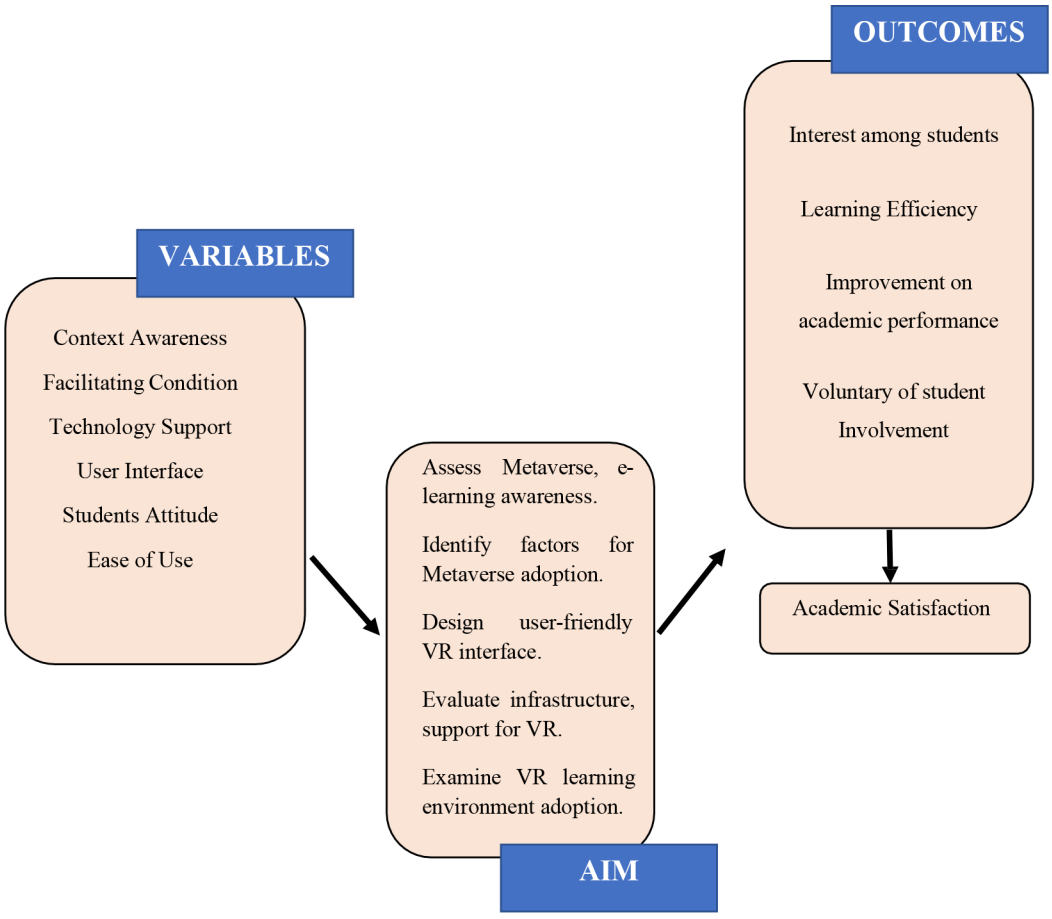
enhance Metaverse adoption among students (Salloum *et al*., 2023). However, to contribute significantly, the interface quality, perceived usefulness, and facilitating conditions to be the most significant factors in student satisfaction related to Metaverse adoption and highlighted the significance of user-centered design in immersive learning (Koppelaar *et al*., 2024). Recently, Maghaydah *et al.,* (2024) developed an all-encompassing model for the adoption of Metaverse in education, grouped into psychological, quality, social, and inhibiting factors which influence the student engagement, satisfaction, and intention towards Metaverse. Based on the existing literature, the current studies have contributed to the overall understanding of the significant factors leading to Metaverse adoption among students. However, to our knowledge, the impact of Metaverse adoption among engineering students have received little attention and this study explores the engineering students' attitude and institutional support in adopting Metaverse for building inclusive, interactive learning spaces which equip students for a technology-led global economy.

3. Research Gap

Though, Metaverse has gained increasing attention as a tool for interactive learning, the researcher identified several research gaps in the literature reviews, particularly within the context of engineering education. They are,

1. Limited research in the Indian engineering education context regarding Metaverse adoption.
2. Lack of empirical evidence on student awareness and attitudes related to Metaverse experience.
3. Only few studies focusing on infrastructure constraints and accessibility issues in Institutions.
4. There was insufficient exploration of institutional readiness for Metaverse adoption.

4. Research Model



Context Awareness Facilitating Condition Technology Support User Interface Students Attitude Ease of Use

Assess Metaverse, e- learning awareness. Identify factors for Metaverse adoption. Design user-friendly VR interface. Evaluate infrastructure, support for VR. Examine VR learning environment adoption.

5. Methodology

5.1 Instrument Measures

A structured questionnaire was administered to gather information from engineering students in Tamil Nadu. A5-point Likert scale was used to capture awareness and influence of Metaverse and e-learning. The scale used was a "Strongly Disagree" to "Strongly Agree" with close-ended questions. The items were constructed utilizing the item analysis method to determine discriminatory validity. Only those statements that clearly differentiated between high and low scorers were kept.

5.2 Reliability Analysis

Reliability check was done to check the reliability of the questionnaire.

Cronbach's alpha value is 0.825 which means questionnaire is highly reliable.

A sample of 25 was taken to test the validity and reliability of the questionnaire.

Table 1. Reliability check

Reliability Statistics	
Cronbach's Alpha	No. of Items
0.825	25

5.3 Data Analysis

The population for this study is finite and to obtain a representative sample for the study, a non-probability sampling technique was employed. Specifically, convenience sampling was used. Convenience sampling is a non-probability method where participants are selected based on their availability and willingness to take part in the study. Engineering students were chosen as participants due to their easy accessibility and relevance to the research objectives.

For choosing sample size, the following formula was used and the sample size estimated to 384 but due to time constraint 183 samples were finally derived.

$$\underline{n = N.\ Z2.\ p.\ (1-p)}$$
$$(e2.\ (N-1)) + (Z2.\ p.\ (1-p))$$

Demographic analysis: With the gender of the respondents 42.6% are female and 54.1% are male.

6. Results and Discussion

6.1 Factor Analysis

Factor analysis of all variables from the questionnaire

Table 2. KMO and Bartlett's test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.918
Bartlett's Test of Sphericity	Approx. Chi-square	1978.731
	Df	190
	Sig.	0.000

7. Interpretation

From the Table 1 it is inferred that KMO value of 0.918 indicates excellent suitability for factor analysis, as it shows strong shared variance among variables. Bartlett's test, with a significant p-value of 0.000 and a chi-square of 1978.731, confirms that the variables are highly correlated, rejecting the idea of an identity matrix. This suggests the questionnaire data is appropriate for factor analysis. The strong correlation ensures meaningful factors can be extracted.

From the Table 2, it is inferred that Communalities reflect how much of each variable's variance is explained by the extracted factors, ranging from 0.491 to 0.730. Higher values, like 0.730 for peer support, show that these variables are well-represented by the factors, while lower values, like 0.491 for comfort with VR, indicate less explained variance. Most variables have moderate to high communalities, suggesting the factors capture a good portion of the data's variance.

From the Table 3, three factors with eigen values greater than1explain 59.573% of the total variance, a solid

amount for social science research. The first factor accounts for 45.472%, the second 8.199%, and the third 5.902%, with rotation redistributing variance to 24.686%, 19.194%, and 15.692% for better interpretability.

From the Table 4, the first reflects knowledge and perceived benefits of VR (*e.g.*, awareness, engagement), the second focuses on adaptation and ease of use (*e.g.*, guidance, peer support), and the third highlights institutional support (*e.g.*, infrastructure, technical help). Variables load strongly (mostly >0.4) on these factors, showing clear associations.

8. Findings

Factor analysis was used to identify the dimension and reduce the number of variables, and also it is used to check the validity and of the questionnaire. Application of principal component analysis using SPSS was to investigate the latent factor linked to these 20 items. It is inferred that,

1. Variable (06) awareness of VR learning method has very high significant loading factor (.744) under the technical skills- digital literacy.
2. Variable (11) attitude of students towards VR have very high significant loading factor (.653) under the affective skill-engagement willingness.
3. Variable (14) user-friendly interface in VR have very high significant loading factor (.580) under the technical skill -interface navigation.
4. Variable (18) facilitating conditions in VR have very high significant loading factor (.386) under the technical skill -infrastructure awareness.
5. Variable (23) adoption to VR learning environment have very high significant loading factor (.265) under the technical skill - practical proficiency.

9. Implications and Suggestions

1. Institutions are advised to provide students and teachers with specialized training programs on Metaverse specifically to engineering courses. Offering workshops for VR equipment, including headsets and software, would assist in increasing knowledge and familiarization with such technologies among users.

Table 3. Communalities

	Initial	Extraction
I am knowledgeable about the current technological tools that support virtual reality learning method.	1.000	.634
I am aware of how virtual reality can be integrated into educational setting.	1.000	.541
I can distinguish between traditional e-learning platform and the immersive experience by virtual reality.	1.000	.584
I understand the potential benefits of using the virtual reality for enhancing e- learning experience.	1.000	.626
I feel comfortable with the using of virtual reality for learning purposes.	1.000	.627
I think virtual reality learning method will enhance my engagement and participation in class activities.	1.000	.542
I believe adopting virtual reality learning method will improve my overall academic performance and learning experience	1.000	.470
I am excited about the possibility of using virtual reality learning in my studies.	1.000	.610
I feel comfortable with user interface VR platform.	1.000	.574
A simple user interface would make me more likely to adopt virtual reality learning method.	1.000	.579
The ease of accessing features in virtual reality learning platform significantly influence my willingness to use it.	1.000	.529
A well-designed user interface would enhance my learning experience in a virtual reality-based learning.	1.000	.530
I feel the infrastructure at my institution is capable of supporting immersive virtual reality learning experience.	1.000	.631
My institution provides the necessary devices and software to support virtual reality-based learning.	1.000	.550
I receive adequate guidance and training on how to effectively use virtual reality learning platform.	1.000	.676
My institution offers technical support to help resolve issues with virtual reality learning platform.	1.000	.526
Clear instructions and guidance improve my ability to adapt to new learning environments like the virtual reality-based learning.	1.000	.502
I believe hands-on practice with virtual reality learning platform would help me better adapt to this new learning environment.	1.000	.513
I feel that peer support and collaboration make it easier for me to adapt to virtual reality-based learning environments.	1.000	.586
Orientation and training provided by my institution helpful in understanding how to use virtual reality-based platforms.	1.000	.616

Table 4. Total variance explained

Component	Initial Eigen Values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	9.094	45.472	45.472	9.094	45.472	45.472	4.937	24.686	24.686
2	1.640	8.199	53.671	1.640	8.199	53.671	3.839	19.194	43.881
3	1.180	5.902	59.573	1.180	5.902	59.573	3.138	15.692	59.573
4	0.906	4.528	64.101						
5	0.783	3.914	68.014						
6	0.716	3.578	71.593						
7	0.632	3.159	74.751						
8	0.579	2.896	77.648						
9	0.567	2.837	80.485						
10	0.517	2.586	83.071						
11	0.497	2.484	85.555						
12	0.478	2.391	87.946						
13	0.434	2.172	90.118						
14	0.382	1.912	92.030						
15	0.346	1.732	93.762						
16	0.310	1.551	95.314						
17	0.265	1.325	96.639						
18	0.255	1.275	97.914						
19	0.225	1.124	99.038						
20	0.192	0.962	100.000						

Extraction method: Principal component analysis

Table 5. Rotated component matrix

Rotated Component Matrix			
Description	Component		
	1	2	3
Technical skills-digital literacy.	0.744	0.037	0.107
Cognitive skills-conceptual understanding.	0.696	0.268	0.150
Cognitive skills-analytical Thinking.	0.738	0.070	0.277
Cognitive skills-evaluation and decision-making	0.664	0.195	0.226
Technical skills-device operation.	0.472	0.500	0.135
Affective skill-engagement willingness	0.653	0.415	0.091
Cognitive skills-predictive reasoning.	0.536	0.519	-0.016
Affective skill-technology enthusiasm.	0.555	0.408	0.175
Technical skill-interface navigation.	0.580	0.285	0.306
Affective skill-positive attitude towards simplicity.	0.579	0.434	0.231
Technical skill-functional usability.	0.503	0.492	0.278
Affective skill-motivation through design.	0.574	0.435	0.247
Technical skill-infrastructure awareness.	0.386	0.249	0.621
Motivational skills-readiness awareness.	0.168	0.207	0.783
Social skills-training responsiveness.	0.173	0.093	0.800
Collaborative skills-help-seeking and communication.	0.159	0.294	0.781
Cognitive skill-instructional comprehension.	0.256	0.682	0.253
Technical skill-practical proficiency.	0.265	0.697	0.304
Social skill-collaborative learning	0.134	0.826	0.172
Collaborative skills-adaptability through structured support	0.174	0.574	0.445

Extraction method: Principal component analysis

2. Educators are advised to illustrate VR's characteristics through interactive workshops to make the students for great engagement.
3. It is recommended for Developers and Institutions to create intuitive and easy-to-use interfaces within the learning environment. This will ensure smooth and comfortable use for users of VR platforms.
4. It would be beneficial for Institutions to invest in stable infrastructure, such as high- speed internet and VR-compatible equipment. Periodic maintenance and upgrading would ensure a stable and uninterrupted VR learning experience that might improve the learning capabilities of students.
5. Institutions can consider offering specific VR labs or practice sessions to assist students in familiarizing themselves with the technology. This first-hand experience will make their transition smoother and enhance confidence in adopting the VR learning environment.

10. Conclusion

The present study analyses awareness, attitude, enabling conditions, and implementation of Virtual

Reality (VR)-enabled learning among engineering students in Tamil Nadu. The results indicate that the students are well aware of VR tools and keen on their adoption in education, appreciating VR's immersive benefits compared to generic e-learning platforms. Nonetheless, support from infrastructure, counseling, and access to devices is moderate, placing emphasis on aspects in need of improvement at an urgent level. Positive attitudes of students towards VR are associated with their perceptions and awareness of how easy VR is to use, supporting the significance of people-oriented platform design. Practice hands-on, peer assistance, and explicit instructions play a crucial role in successful VR implementation. Institution needs to upgrade their technology infrastructure, offer strong training, and reorganize curricula to complement VR adoption. Success depends on overcoming infrastructure, user interface design, and support system challenges despite the enthusiasm of students. By focusing on these, institutions can take advantage of VR's possibilities to enhance participation, engagement, and learning, equipping next-generation engineers to thrive in the technology-intensive world through creative, accessible learning environments.

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