Exploring Student Morale through Technology Acceptance Model in Higher Education: A Study of AR-Based E-Learning Application

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***Abstract*-** This study examines the relationship between student morale and e-learning applications in higher education by employing the Technology Acceptance Model (TAM) as a framework. Augmented Reality (AR) usage is the primary focus of this research. The objective of this research is to examine the effects of incorporating augmented reality (AR) technology on student satisfaction and engagement within educational environments. An examination was conducted on different facets of user behavior and interaction patterns via a quantitative survey that was distributed to students utilizing e-learning applications. Many aspects of user perception and interaction are investigated using quantitative analysis of survey responses gathered from students employing an augmented reality (AR) e-learning platform. The results indicate that students exhibit a considerable degree of engagement with interactive components in augmented reality (AR) materials and demonstrate a clear preference for collaborative endeavors involving both instructors and peers. Moreover, the students demonstrate a favorable attitude towards the augmented reality (AR) based e-learning application, articulating strong probabilities of sharing and subsequent utilization. In general, the research highlights the capacity of augmented reality (AR) technology to boost student engagement and morale in tertiary education environments. As a result, it provides instructional designers and educators with valuable knowledge regarding how to optimize learning outcomes through the use of emergent technologies.

***Index Terms*-** Augmented Reality, E-Learning Application, Technology Acceptance Model

I. Introduction

Augmented reality (AR) and Virtual reality (VR) are technologically significant innovations that enable the merging of the digital and physical realms. In spite of the frequent misunderstandings that conflate their functionalities, it is critical to differentiate the unique characteristics that are integral to each. Virtual reality (VR) creates immersive experiences that can closely resemble or completely differ from reality. This is achieved using advanced software-driven interfaces, which empower users to interact with and perceive virtual environments in a way that is rich in sensory stimuli [1]. On the other hand, augmented reality adds computer-generated improvements onto physical environments, thereby enhancing perception through various sensory modalities [1]. The growing popularity of virtual reality (VR) and augmented reality (AR) applications surpasses the domain of entertainment and enters various sectors, including education, healthcare, and commerce. These technologies have significant potential, especially in educational settings, by relying on the advanced technological skills exhibited by modern student populations [2]. Significant potential exists for augmented reality (AR) to enhance student morale through the facilitation of realistic and exciting learning experiences. Through the seamless incorporation of digital components into the real-world setting, augmented reality (AR) possesses the capability to attract students and stimulate their natural curiosity, consequently fostering a fervent interest and eagerness to learn. AR-enhanced activities provide students with a unique and creative chance to engage with educational material, exceeding the constraints imposed by traditional instructional techniques. In addition to fostering a more profound comprehension of academic principles, this interactivity empowers and promotes in students an awareness of control and independence over their educational trajectory. In addition, augmented reality enables customized learning experiences that are founded on the interests and learning styles of each individual, enabling learners to traverse academic content at a self-determined rate and in alignment with their distinct areas of interest. AR enhances student confidence and morale by converting passive learners into active participants, thereby cultivating a sense of accomplishment and self-efficacy. Moreover, the sensory engagement induced by the immersive characteristics of augmented reality (AR) environments improves the retention and comprehension of scholarly material. Consequently, augmented reality (AR) not only surfaces as a potent instrument for education but also acts as a catalyst in creating favorable inclinations towards learning, thereby ultimately enhancing student morale and academic achievements [3]. Given the widespread availability of the internet and the prevalence of gaming experiences, educational institutions are faced with the necessity of reassessing their pedagogical approaches in order to effectively engage learners who are accustomed to using digital devices [4]. By combining virtual reality (VR) and augmented reality (AR), educators have the ability to create immersive learning experiences that effectively merge virtual components with real-life situations. This results in increased student engagement and comprehension [5]. The impact of augmented reality extends beyond academic

environments, reaching sectors including business, healthcare, and public safety, where it holds the potential to provide concrete benefits and novel approaches [6]. Recent academic articles highlight the profound impact that augmented reality (AR) can have on various fields, including primary education, specialized disciplines such as anatomical education and cardiology, and the facilitation of knowledge acquisition [8], [9], [10]. Given the continued significance of efficiently accessing information regarding nearby objects and engaging with them, augmented reality (AR) comes up as a critical instrument that can improve human perception and interaction with the concrete surroundings [11]. The initial concept of augmented reality (AR) can be traced back to influential publications by Ivan Sutherland and was subsequently elaborated upon by Paul Milgram and Fumio Kishino. This conceptualization emphasizes the goal of augmenting perceptions of the physical world with additional digital data, thus broadening the parameters of reality [7], [13]. AR technology has become a prominent subject of study in computer science research. It serves as a prime example of how digital content can be seamlessly integrated with real-world environments to facilitate interactive and enhanced learning experiences [12]. This research attempts to enhance the collective knowledge of the extensive effects of augmented reality (AR) technology in various fields by examining its historical development, present-day utilization, and potential future developments. In doing so, it will take advantage of influential papers by esteemed individuals including Morton Heilig and many more [14].

II. Literature Review

It has been acknowledged that the inclusion of technology into educational procedures stimulates active learning environments, which in turn increases student motivation and engagement, and ultimately contributes to the learning process's efficacy. Nevertheless, academic research has revealed a significantly positive results for the learning experiences, especially when the employed tools enhance the critical thinking, meaningful engagement, or metacognitive processes [16]. Augmented reality (AR) presents itself as a possibly revolutionary technological solution within this particular framework, as it enables instantaneous engagement with virtual applications and thus enhances the learning experience with greater complexity and engagement. Augmented reality (AR) possesses remarkable potential for clarifying and explaining complicated educational topics because of its distinctive ability to effortlessly combine digital material with physical environments. Using augmented reality (AR) to overlay multimedia content onto real-world items or spaces provides students with an engaging and immersive learning experience that surpasses conventional methods of instruction. This technological advancement empowers instructors to render complex or abstract ideas into concrete and familiar forms, accordingly, augmenting understanding and long-term retention. AR applications provide learners with the ability to visually perceive detailed occurrences, control digital examples, and participate in interactive simulations, thereby facilitating greater understanding of difficult topics. Additionally, augmented reality (AR) enables customized and adaptable learning experiences, enabling learners to investigate material at their preferred speed and in manners that accommodate their unique learning preferences. Through the utilization of augmented reality's capabilities, instructors have the capacity to convert learning environments into vibrant and captivating settings that simplify intricate subjects, rendering them understandable, and eventually, memorable for students of diverse aptitudes and backgrounds. [15]. The integration of augmented reality (AR) technology into learning activities has garnered growing academic interest due to its capacity to fully engage learners in genuine and lifelike experiences [17]. Significantly, prior studies have attempted to utilize augmented reality (AR) to simplify difficult topics, as evidenced by endeavors that focus on the humanities and natural sciences and exploit AR's ability to incorporate multimedia components and enhance the learning environment [18]. These initiatives highlight the revolutionary capacity of augmented reality (AR) to surpass conventional pedagogical limitations and promote more profound comprehension and retention of scholarly material. Furthermore, academic discussions have explored the wider ramifications of augmented reality (AR) and virtual reality (VR) technologies in the field of education, emphasizing their capacity to foster vital workforce competencies and improve academic achievements [16]. Nevertheless, notwithstanding their potential, obstacles endure, specifically in the realm of reproducing practical laboratory procedures and operating apparatus via virtual mediums. As a result of these obstacles, the development of agile methodologies and effective processes for the development of AR and VR applications that fits the educational settings is an absolute necessity. The current research aims to tackle this pressing issue by introducing an innovative augmented reality (AR) learning tool that offers comprehensive insights into a range of educationally pertinent objects, devices, or tools. By capitalizing on the adaptability and accessibility of Unity software [19] and the features of Vuforia SDK [20], this application seeks to integrate virtual components with physical surroundings in a seamless manner, with the goal of enhancing educational experiences and promoting more profound understanding. This literature review is situated within the wider discussion on the incorporation of augmented reality (AR) into educational environments. It incorporates findings from various research domains, such as virtual training and AR user interfaces. Significantly, it draws inspiration from influential pieces of work such as Spellbound, an augmented reality interface that utilizes interactive experiences to connect the realms of reality and virtuality. Although Spellbound's main focus is on entertainment, its fundamental principles align with the pedagogical capabilities of augmented reality, underscoring its capability to simplify intricate subjects and improve understanding. Within the fields of STEM education, educational technology, and augmented reality (AR), the user experience of an AR e-learning application that is intended to educate is a critical metric. To assess the effectiveness and usability of the chapter on work and energy, a group of scientists utilized the System Usability Scale. This inquiry emphasizes the significance of applying user-centric design principles when creating augmented reality (AR) educational tools. It further accentuates the necessity for intuitive interfaces and captivating learning experiences in order to maximize student engagement and improve learning outcomes. Further, these hyperpedagogies expand their boundaries by incorporating robotic kits into STEM education, which

emphasizes playful learning approaches to encourage student engagement and participation in the fields of science, technology, engineering, and mathematics. Through the incorporation of practical experimentation and investigation utilizing digital technologies, this research showcases the capacity of experiential learning approaches to augment STEM education within virtual settings. Moreover, an inquiry into the efficacy of an augmented reality (AR)-enabled e-learning application with respect to educational achievements utilizes hybrid pedagogy and VARK analysis to customize teaching approaches in accordance with the varied learning preferences and styles of students. The significance of utilizing adaptive learning technologies and pedagogical strategies to optimize educational experiences and meet the unique requirements of each student. Moreover, temporal complexities are inherent in AR-based hybrid pedagogies utilized to teach physics concepts in secondary schools. This underscores the necessity of addressing time constraints in order to guarantee efficient and effective learning experiences. However, these limitations are surpassed by the significance of custom-built video game simulators in influencing learning outcomes, which emphasizes the criticality of incorporating Universal Design for Learning principles to facilitate accessibility. As a collective, these studies make a significant contribution to the progression of knowledge and comprehension by providing invaluable insights into novel methodologies for instructing and learning in digital settings [22]-[26].

III. METHODOLOGY

Developing an augmented reality (AR) application in Unity via the Vuforia module necessitates the implementation of a methodical procedure comprising multiple pivotal stages. Developers must initially configure their development environment through the installation of Unity and the Vuforia module. They can initiate the process by integrating the Vuforia package into the project assets of a newly created Unity project. By importing the Vuforia module, developers gain access to an extensive array of AR-specific features and functionalities, such as object tracking, image recognition, and augmented reality experiences. Setting up the augmented reality (AR) camera within the Unity scene, which functions as the user's viewport into the augmented reality, is the subsequent critical step. By configuring the augmented reality camera to utilize Vuforia's image tracking and object recognition functionalities, programmers can empower the application to superimpose virtual content onto tangible objects or surfaces. After completing the AR camera configuration process, developers have the ability to utilize Vuforia's target management system to generate and tailor AR targets. This process entails the uploading of images or three-dimensional models that will function as targets for recognition in the augmented reality application. After the targets have been specified, developers have the ability to create and incorporate virtual content that will be presented when the AR camera detects the targets. This can include 3D models, animations, or interactive elements. By harnessing the robust rendering capabilities of Unity, developers are able to meticulously customize the visual and functional aspects of virtual content in order to produce immersive augmented reality experiences. Lastly, exhaustive optimization and testing are required to guarantee that the augmented reality application operates flawlessly across a variety of environments and devices. By utilizing the functionalities offered by the Vuforia plugin and adhering to best practices for augmented reality (AR) development, programmers have the ability to fabricate interactive and captivating AR applications that serve as a bridge between the virtual and real worlds. Augmented reality (AR) applications comprise an extensive array of functionalities and use cases, wherein each provides distinctive experiences customized to particular contexts and user requirements. To begin with, marker-based augmented reality (AR) applications utilize predetermined markers, including QR codes or images, to activate virtual overlays and enhance the user's physical surroundings with digital content. In contrast, markerless augmented reality (AR) fixes virtual elements in physical environments by leveraging environmental characteristics such as visual recognition, GPS, or accelerometer data, thereby eliminating the requirement for markers. By projecting digital content onto tangible surfaces or objects, projection-based augmented reality generates immersive experiences in real-world settings. Location-based augmented reality (AR) applications utilize GPS and geolocation data in order to superimpose digital information onto tangible locations, thereby providing users with experiences that are contextually pertinent to their immediate environment. Additionally, augmented reality (AR) gaming applications enhance immersion and enjoyment by integrating virtual elements into the physical environment to create interactive gameplay experiences. AR applications for industry and business optimize processes, deliver remote support, and conduct training simulations through the superimposition of digital data onto tangible objects or surroundings, thereby enhancing output and efficiency. Using a hybrid pedagogical approach, this study investigates the pedagogical implications of employing low polygon count 3D models as opposed to high polygon count 3D models in augmented reality (AR) environments. The investigation holds importance in examining the pedagogical effectiveness of utilizing models with varying degrees of complexity in augmented reality (AR) instructional environments.

Figure 1 Low Polygon 3D Model View 1

Through the integration of elements from conventional and innovative pedagogical approaches, this research endeavors to investigate the impact of 3D model complexity on student

engagement and learning outcomes in augmented reality-based educational experiences.

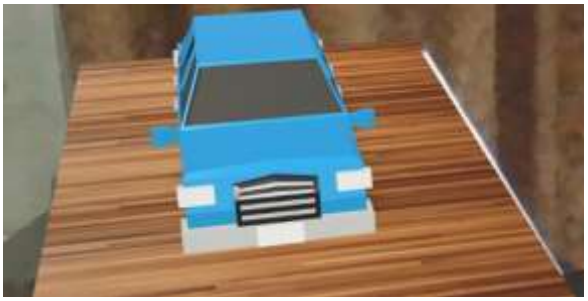

Figure 2 Low Polygon 3D Model view 2

By conducting a comprehensive analysis of pedagogical approaches based on hybrid pedagogy, this study aims to offer significant contributions to the field of instructional design strategies for augmented reality (AR) learning environments. The comparative analysis of high polygon count 3D models and low polygon count 3D models in the context of augmented reality is fundamental to this research.

Figure 3 High Polygon 3D Model View 1

Low polygon models, which have simplified geometry and diminished detail, provide benefits such as enhanced performance and effective visualization. As a result, they are well-suited for augmented reality applications that have limited resources.

Figure 4 High Polygon 3D Model View 2

Conversely, models with a high polygon count exhibit elaborate intricacy and realism, thereby augmenting visual fidelity albeit potentially placing a strain on system resources. The purpose of this research is to clarify the instructional implications of these various model types in order to establish which ones are most effective at facilitating learning experiences in augmented reality environments. Moreover, the research endeavors to analyze the potential of hybrid pedagogical strategies—which combine aspects of conventional and cutting-edge teaching methods—in order to optimize the educational benefits associated with various intricacies of 3D models utilized in augmented reality-based education.

Figure 5 High Polygon 3D Model View 3

A thorough examination of the extant body of literature concerning augmented reality (AR) technology, pedagogical theories, and instructional design principles constitutes the research methodology. By utilizing conceptual frameworks including constructivism, connectivism, and experiential learning, this research endeavors to establish a comprehensive understanding of how the complexity of 3D models influences augmented reality-based pedagogy in an educational setting. Furthermore, qualitative analyses, user studies, and empirical investigations will be undertaken to determine the effect of 3D models with low and high polygon counts on student learning outcomes, engagement, and satisfaction in instructional environments enhanced with augmented reality. By conducting an in-depth analysis of practical implementations and theoretical underpinnings, this research endeavors to produce facts-based knowledge regarding the most effective way to incorporate 3D models of different degrees of complexity into augmented reality-based educational practices. This study aims to make an academic contribution to the rapidly expanding domain of augmented reality in education through an investigation into the pedagogical consequences of employing three-dimensional models with low and high polygon counts in augmented reality environments. Through the implementation of a hybrid pedagogical strategy that integrates conventional instructional techniques with cutting-edge technological instruments, this research endeavors to clarify the impact of 3D model complexity selection on student engagement and learning outcomes in augmented reality-based educational encounters. By conducting an extensive inquiry that incorporates theoretical examination, empirical study, and practical implementation, this research endeavors to provide insights for instructional design methodologies and improve the efficacy of augmented reality-based pedagogy in fostering significant and influential learning encounters.

IV. Results and Discussion

The responses to the survey demonstrate that the AR-based e-learning application was received exceptionally well by the students. A considerable proportion of students strongly concur that the augmented reality (AR) functionalities substantially augment their educational voyage, are in perfect harmony with

course objectives, and exhibit user-friendly navigation. This indicates that the incorporation of AR technology has yielded positive outcomes for their academic pursuits. Furthermore, there is a unanimous consensus among students that engaging with augmented reality (AR) components is effortless and instinctive, and that the visual depiction of AR material is vivid and unambiguous, thereby augmenting both involvement and understanding of intricate ideas. The positive feedback also encompasses the motivational dimension, as students express that augmented reality (AR) functionalities inspire them to participate more actively in course materials and enhance the overall learning experience. Moreover, it has been observed that students regard augmented reality (AR)-based exercises as efficacious instruments that augment their comprehension of intricate subjects. This finding implies that AR promotes more profound learning and the retention of knowledge. Additional evidence of the students' profound contentment is their inclination to enthusiastically endorse the augmented reality (AR) e-learning application to others, which signifies their conviction in its caliber and efficacy. In summary, these findings emphasize the considerable capacity of augmented reality (AR) technology to augment the scholastic encounter, encourage active participation, and facilitate favorable learning results.

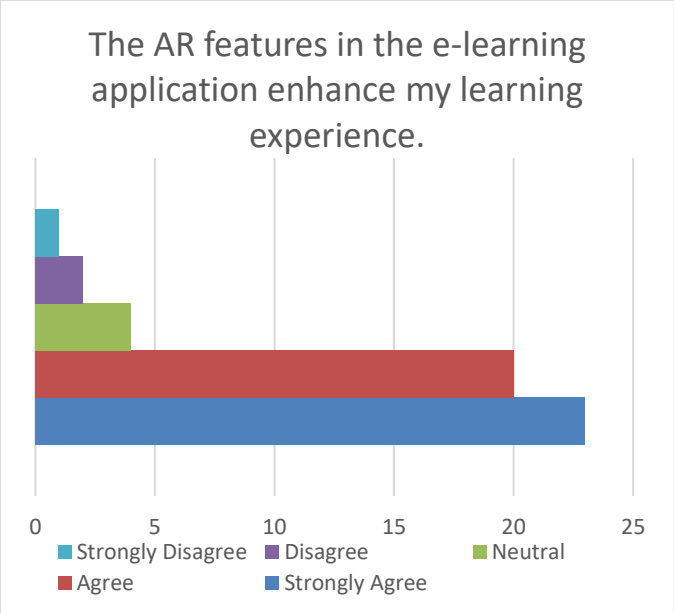

Figure 6 Technology Acceptance Model Question 1

Figure 6 implies that students consider augmented reality to be a beneficial instrument that enriches their educational experience. Students express their agreement or strong agreement with the statement that augmented reality (AR) features make a positive contribution to their educational experience. This statement suggests that the integration of augmented reality (AR) components into the e-learning platform can result in increased engagement, interactivity, and comprehension of course materials. AR may facilitate practical learning through the provision of simulations that enable hands-on experience, interactive quizzes that reinforce learning objectives, or visualizations that elucidate abstract concepts.

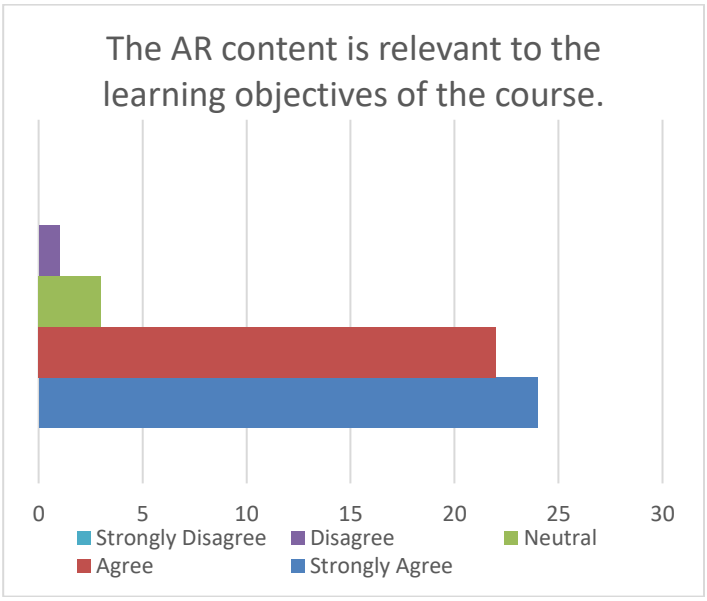

Figure 7 Technology Acceptance Model Question 2

The fact that students agree or firmly agree that augmented reality (AR) content is in line with course objectives indicates that the AR materials have been integrated into the curriculum with care. This alignment guarantees that augmented reality (AR) contributes to the learning process rather than detracts from it. It signifies that augmented reality (AR) material serves to strengthen fundamental ideas, facilitates the achievement of educational goals, and offers significant prospects for practical implementation and refinement. For example, augmented reality (AR) simulations could replicate real-life situations that are pertinent to the subject matter of the course, thereby providing students with opportunities to implement theoretical understanding in practical settings.

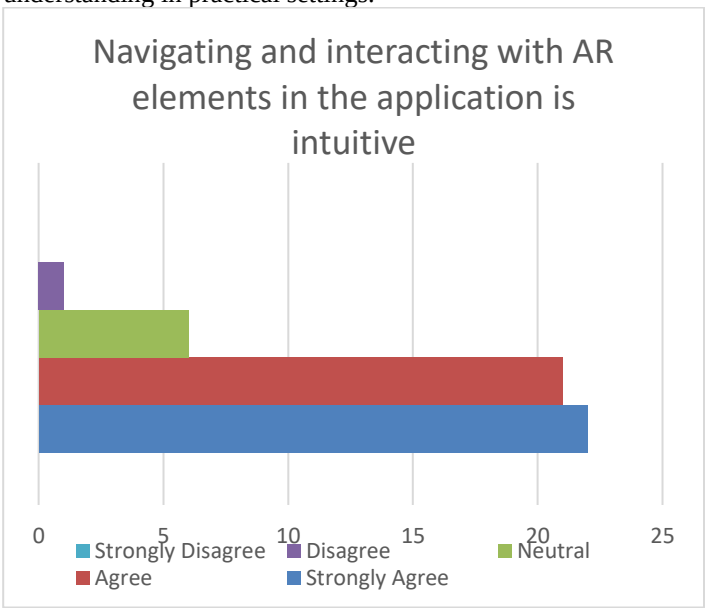

Figure 8 Technology Acceptance Model Question 3

Figure 8 illustrates the agreement or strong agreement of students with this statement signifies that they perceive the interaction with augmented reality (AR) elements as effortless and intuitive. It indicates that intuitive navigation and simplicity of use are

prioritized in the design and implementation of augmented reality features. The favorable user experience promotes a feeling of assurance and ease when interacting with augmented reality (AR) materials, enabling learners to concentrate on the learning process instead of contending with intricate technical aspects. Intuitive interaction design encompasses elements such as unambiguous directives, prompt responses, and intuitive controls or gestures.

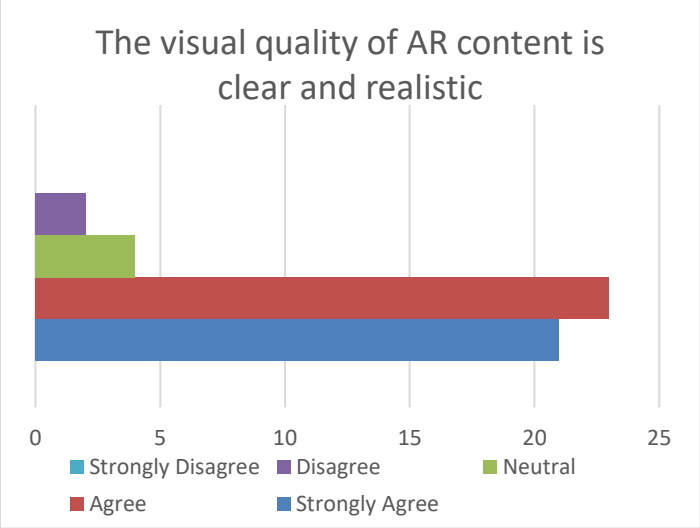

Figure 9 Technology Acceptance Model Question 4

Students concur or strongly agree that the visual presentation of augmented reality (AR) content is clear and realistic, indicating that the visual quality of AR meets or surpasses their expectations (see figure 9). This suggests that augmented reality components are rendered with high quality, aesthetically pleasing, and efficiently communicate data. The use of realistic visuals facilitates greater engagement and immersion, thereby simplifying the comprehension of intricate concepts. Ensuring a visually coherent presentation of augmented reality (AR) content enables students to comprehend it without any uncertainty or perplexity, thereby promoting efficacious learning encounters.

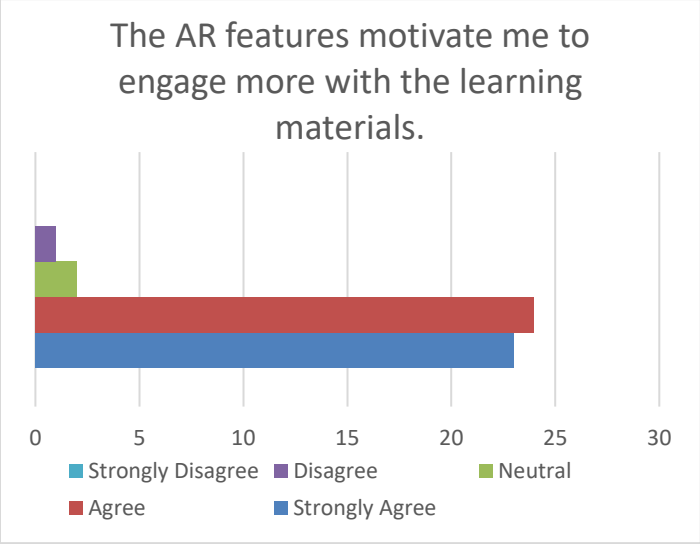

Figure 10 Technology Acceptance Model Question 5

Regarding figure 10 the agreement or strong agreement of students with this statement suggests that augmented reality (AR) features are efficacious in stimulating heightened involvement with course materials. The dynamic and interactive characteristics of augmented reality captivate students' attention and motivate them to engage actively in educational tasks. A multitude of elements can inspire motivation, including the novelty of augmented reality (AR) technology, the gamification of educational experiences, and the instantaneous feedback offered by AR interactions. Enhanced levels of engagement facilitate more profound learning, increased participation, and improved knowledge retention.

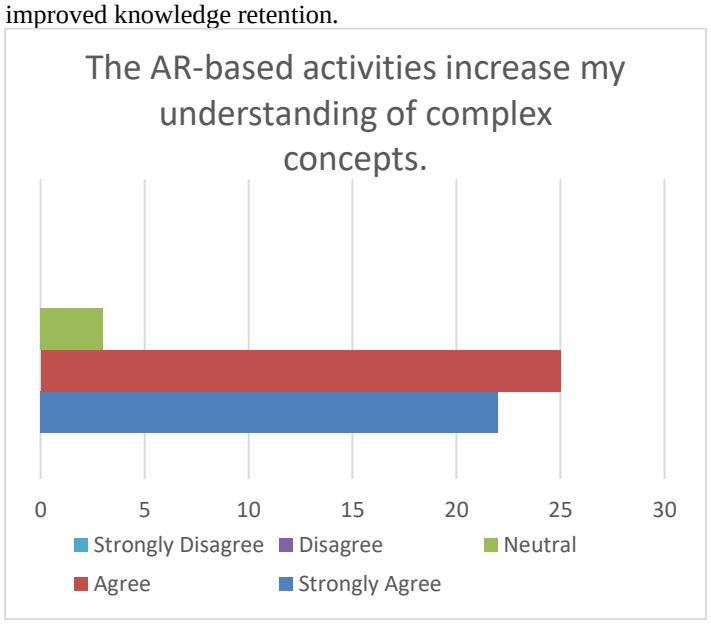

Figure 11 Technology Acceptance Model Question 6

In figure 11 Students' agreement or strong agreement that augmented reality (AR) activities improve their comprehension of intricate concepts indicates that AR facilitates retention and comprehension, thereby effectively supporting learning outcomes. AR activities offer interactive and visual depictions that simplify difficult or abstract concepts, thereby rendering them more palpable and understandable.

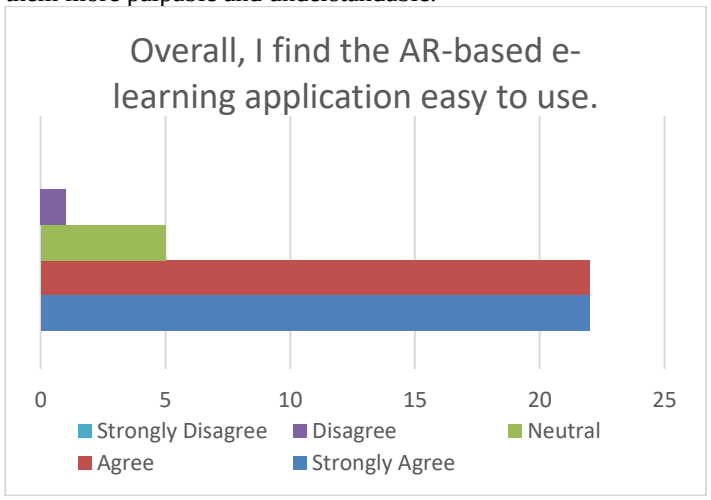

Figure 12 Technology Acceptance Model Question 7

Through the development of a richer comprehension of intricate subject matter, students acquire more profound insights, establish connections between theoretical knowledge and practical situations, and experience concepts in an interactive and immersive fashion. The level of agreement or significant agreement among students regarding this statement suggests that they consider the augmented reality (AR) e-learning application to be accessible and user-friendly. This implies that the interface and navigation design of the platform are user-friendly, enabling pupils to effortlessly find and utilize educational resources, tools, and functionalities.

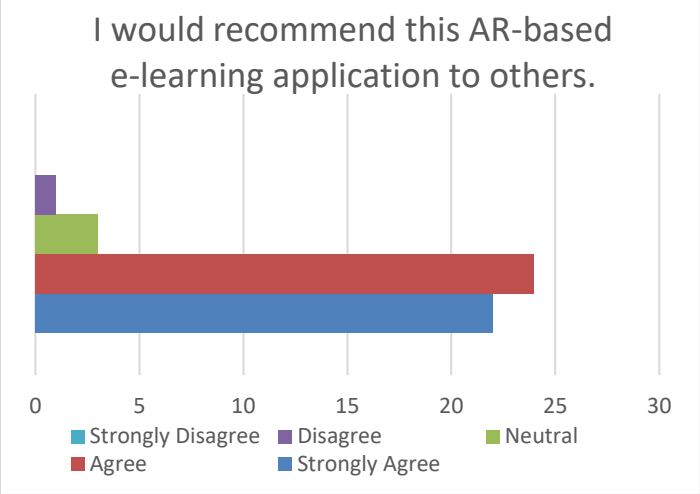

Figure 13 Technology Acceptance Model Question 8

An effectively planned navigation system reduces cognitive burden, mitigates user frustration, and improves overall usability, thereby enhancing the overall user experience. The implementation of intuitive navigation enables students to navigate the learning environment confidently and effortlessly, thereby promoting efficiency, autonomy, and engagement. Students' inclination to endorse the augmented reality (AR) e-learning application to others indicates a substantial degree of contentment and trust in the platform's efficacy and caliber. This recommendation suggests that students consider the augmented reality (AR) application to be advantageous and valuable, thus justifying its endorsement by peers or colleagues.

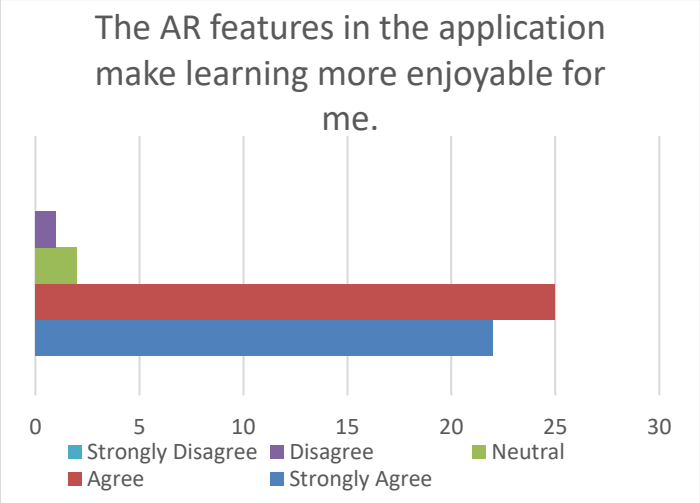

Figure 14 Technology Acceptance Model Question 9

Positive recommendations enhance the credibility and adoption of a platform by providing social substantiation regarding its effectiveness, dependability, and value proposition. Students' confidence in endorsing the application signifies their faith in its capacity to provide significant learning opportunities and successfully accomplish intended academic results. The strong agreement or agreement of students with this statement suggests that augmented reality (AR) functionalities augment the overall enjoyment of the educational process. This indicates that AR technology enhances the educational experience with an element of enjoyment, intrigue, and involvement. Positive emotions, intrinsic motivation, and a sense of accomplishment are all promoted by enjoyable learning experiences, all of which are conducive to successful learning outcomes. AR's interactive and immersive characteristics revolutionize conventional learning endeavors, converting them into captivating and gratifying experiences that cultivate a more profound affinity for course content and encourage enduring curiosity and eagerness towards acquiring knowledge.

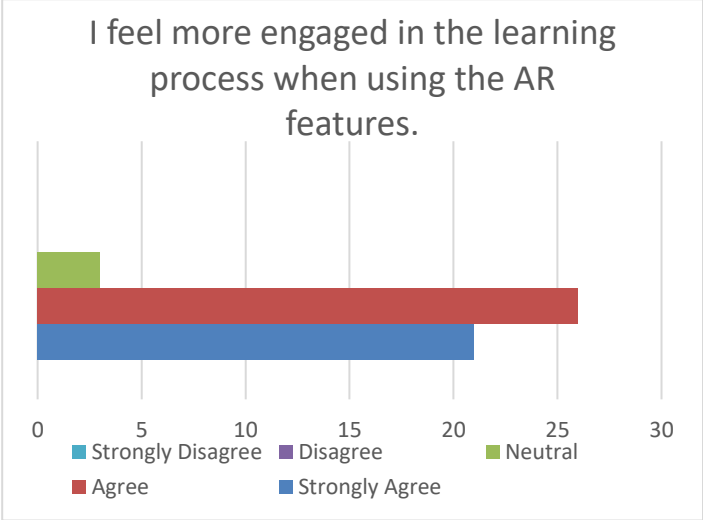

Figure 15 Technology Acceptance Model Question 10

The firm consensus among students indicates that augmented reality (AR) functionalities promote active involvement and participation among students during the educational journey. This suggests that augmented reality (AR) technology promotes pupil engagement in the learning process, as opposed to a passive reception of information. Active engagement is characterized by inquiries, reflections, and interactions that foster critical thought, problem-solving, and a more profound comprehension. Students are inspired to investigate, experiment, and collaborate because of the interactive and experiential qualities of augmented reality (AR), which fosters more profound learning experiences marked by curiosity, exploration, and revelation. Active engagement fosters increased levels of participation, ownership, and enjoyment, which ultimately contribute to improved academic achievements and learning outcomes.

V. CONCLUSION

As a result of its findings, this research provides insight into the substantial impact that augmented reality (AR) technology has on student engagement and morale in higher education settings. Several crucial insights have surfaced from the examination of

Technology Acceptance Model survey responses provided by students who utilize augmented reality (AR)-based e-learning applications. To begin, students exhibit proactive involvement with augmented reality (AR) functionalities, regularly employing them and devoting significant amounts of time to AR-enhanced learning endeavors. AR's efficacy and desirability in facilitating immersive and interactive learning experiences are underscored by the substantial degree of engagement exhibited by users with the interactive components present in its content. Furthermore, students demonstrate a notable propensity for investigating supplementary augmented reality (AR) resources and participating in cooperative endeavors alongside both instructors and fellow students, thereby emphasizing the social aspect of AR-enhanced learning environments. Significantly, the students demonstrate a favorable attitude towards the augmented reality (AR) e-learning application, as evidenced by their elevated levels of contentment, propensity to recommend, and intention to utilize AR functionalities again in subsequent academic endeavors. The results underscore the capacity of augmented reality (AR) technology to improve academic achievement, student motivation, and morale in higher education. In the future, instructional designers and educators can utilize these insights to enhance the integration of augmented reality (AR) technology into educational practices, thereby cultivating inventive and captivating learning environments that enable students to excel academically. Ongoing investigation and progress in augmented reality (AR)-enhanced learning exhibit potential for improving student achievement in the digital era and propelling educational pedagogy forward.

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