Exploring Temporal Complexities: Time Constraints in Augmented Reality-Based Hybrid Pedagogies for Physics Energy Topic in Secondary Schools

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Abstract- This research investigates the complex aspects of time restrictions that are linked to augmented reality (AR) within the educational domain, specifically emphasizing hybrid teaching approaches. Although the intricacies of hybrid pedagogies are widely recognized, there is still a lack of research on the precise effects of these approaches, specifically regarding time constraints. The primary objective of this study is to fill this void through a thorough investigation of the time-related obstacles that emerge during the incorporation of augmented reality into the educational setting. The study focuses on ninth-grade pupils and examines the subject of energy as it relates to the physics curriculum. The results provide a comprehensive analysis of the extent to which the use of augmented reality lengthens the learning process. It is worth mentioning that the results suggest that AR-based pedagogy requires a considerably longer time commitment in comparison to conventional learning approaches. Additionally, the study identifies a significant determinant that contributes to this discrepancy in time: the facilitators' failure to receive adequate training on how to utilize the augmented reality application effectively prior to the experimental phase. This abstract provides a concise summary of the research's significant discoveries and their implications, elucidating the complex interplay among augmented reality, temporal limitations, and the efficacy of hybrid pedagogies within the realm of education.

Index Terms-Augmented Reality, Hybrid Pedagogy, E-Learning, Gamification

I. Introduction

While education itself is not a recent concept, there have been advancements in educational procedures. In the past, a significant number of individuals lacked the fortune of possessing an innovation that would enhance their education. Currently, there is rapid development and utilization of holistic innovations and special education innovations in both educational and recreational institutions. Teachers and students in education have already developed various new models such as PCs, mobile phones, smart boards, audio recordings, audiovisual apps, educational games, learning platforms, entertainment, augmented reality, Web, and Web 2.0 applications. Scientists are investigating the potential use of augmented reality (AR) in educational settings. Augmented reality (AR) allows for the integration of virtual elements into real environments, facilitating real-time communication. However, there is a paucity of research on the benefits and repercussions of augmented reality (AR) in education. The accessibility of augmented reality has increased due to its ability to be used on mobile devices without requiring specific equipment. The prevalence of mobile augmented reality (AR) applications in the field of education has grown as a result of this phenomenon. Further investigation is required to fully comprehend the extent to which augmented reality (AR) can enhance students' academic performance and motivation to acquire knowledge. A study conducted by the University of Cape Town examined the impact of an augmented reality smartphone application on the level of enthusiasm among undergraduate health science students for learning. The study aimed to measure fluctuations in students' learning motivation by analyzing characteristics such as attention, relevance, confidence, and satisfaction while using the augmented reality app. The subsequent sections of the paper delineate the background, theoretical framework, methodologies, results, and repercussions of the study. Additionally, it proposes areas that should be further explored [1]. The integration of technology into education has yielded excellent outcomes. The integration of technology offers potential to enhance student learning and engagement. Augmented reality (AR) is an emerging technology with potential applications in the field of education. There is a substantial amount of study on Augmented Reality (AR), however there is a scarcity of research specifically focused on education [2].The objective of the present study is to investigate the frequency of AR technology usage and teachers' level of understanding regarding the necessity for consistent training, the procedure for generating 3D models, and the potential for teachers and students to develop AR applications within the school setting. The significance of teacher education lies in the ability of instructors across all fields to approach problems from several angles, draw upon their extensive and diversified educational experience, and effectively manage unforeseen circumstances [3]. Currently, there are emerging advancements in augmented reality within the realm of school education. Notably, recent assessments have demonstrated highly favorable educational outcomes. Augmented reality is infrequently employed in the field of education in Greece. The most frequent applications of this technology are in open archeological sites, indoor environments, and newly developed parks. Thus, in the context of Greek reality, the utilization of continuous reality in the classroom and its implementation to acquire new knowledge was considered a questionable endeavor. The present study seeks to address these two deficiencies and provide additional examination of its educational significance. The rationale for its utilization may offer an additional aspect of the implementation of virtual reality in the instructional process and motivate several scholars to explore its pedagogical advantages, not solely limited to IT education in secondary schools, but also across various topics and educational levels. Provides cutting-edge advancements for professionals and promotes their increased utilization in training. The sector of education has seen substantial transformations with the advent of technological developments. While conventional educational procedures have continued to exist, contemporary approaches have incorporated a diverse array of resources and methodologies to cater to different learning needs. Augmented reality (AR), laptops, cellphones, smart boards, audio-visual software, and instructional games are all crucial components of the modern educational arsenal. Augmented reality has gained considerable attention for its ability to enhance learning experiences by seamlessly integrating virtual elements into real-world situations, allowing for interactive and dynamic engagement. Despite the rapid integration of augmented reality (AR) in several educational domains, there remains a dearth of thorough study regarding its impact on student satisfaction, particularly in relation to e-learning applications. As researchers investigate the possible uses of augmented reality (AR) in educational environments, it becomes increasingly important to assess its effectiveness in enhancing students' motivation to study. The dynamic character of educational innovations is highlighted by Abdul Hayee Baig's research on freelancing tactics for beginners [5] and previous work on interactive STEM in online education [4]. Furthermore, researchers did an investigation on the impact of customized video game simulators on learning [6], while HITEC University students implemented a Smart Aquarium System using the Internet of Things. [7] Offer valuable perspectives on the extensive array of technological applications within the realm of education. The comparative investigation was undertaken by computer experts. The study, which evaluates the influence of augmented reality on academic achievement compared to conventional approaches, makes substantial contributions to the continuing discussion on the efficacy of AR in educational settings. This study aims to build upon previous research by investigating the level of satisfaction stated by students who use an augmented reality (AR) e-learning application focused on a physics topic for ninth graders. Through replicating the research, our goal is to fill gaps in the existing knowledge about the prevalence of augmented reality (AR) technology, the level of awareness among educators about it, and the potential for collaborative development of AR applications in educational environments. Our mission is to undertake a comprehensive evaluation of the educational usefulness of augmented reality in Greece, where its utilization is currently limited. We aim to go beyond its typical usage and provide an in-depth examination of the educational environment. Integrating augmented reality into education offers a promising opportunity to enhance the learning process. The aim of this research is to provide an academic contribution to the ongoing discussion regarding the educational benefits of augmented reality (AR). The findings will have ramifications not only for IT education, but also for a diverse array of subjects and instructional levels. Our goal is to encourage further exploration and utilization of augmented reality by adopting an interdisciplinary approach. This will inspire scholars and practitioners to leverage its possibilities in order to improve the educational experience. AR can be classified as a hybrid technology that encompasses many realities. This is because the technology incorporates virtual things into the user's actual surroundings, enabling them to engage with virtual material. Mobile augmented reality (AR) entails the integration of digital elements into the physical environment using a smartphone camera. Mobile augmented reality (AR) applications such as Pokémon GO enable players to capture different Pokémon in their vicinity, while AR GPS Driving/Walking Navigation offers an AR-based navigation system. Virtual reality and augmented reality are distinct in that virtual reality immerses users in a completely simulated environment, isolating them from the actual world, while augmented reality overlays digital elements onto the real world. In virtual reality, users enter the digital realm through a headset like Oculus Rift or Samsung Gear VR. The significance of virtuality in our world directly influences the specific sort of technology required to facilitate augmented reality (AR), as various display and tracking technologies offer varying degrees of immersion. An example of advanced augmented reality (AR) is the Star Wars Jedi Challenges mobile application, which necessitates the utilization of headphones by users. This study examined the effects of the Anatomy 4D mobile application on the advancement of health students at UCT. Augmented Reality (AR) provides a unique capacity to create immersive and integrated learning environments by seamlessly combining virtual and actual elements. AR technology in education enhances students' comprehension of intricate subjects by granting them access to scientific scenarios that would otherwise be inaccessible, including interactions involving specific chemicals. While it is feasible, the successful incorporation of augmented reality (AR) in the classroom necessitates substantial effort, since students must navigate through vast quantities of information and a range of technical resources to accomplish intricate tasks. The effectiveness of learning methodologies has a substantial impact on students' motivation. Research indicates that augmented reality (AR) has the potential to enhance motivation levels in the field of science education. The ARCS model, a motivational design framework, offers a structured approach to comprehending how augmented reality (AR) technology influences students' motivation to study. It focuses on the factors of Interest, Values, Beliefs, and Interests. The association between trust levels and support underscores the need to create courses that empower students to evaluate their own development. Furthermore, academic inquiries, deliberate surveys, and study applications all substantiate the assertion that augmented reality (AR) applications enhance student performance, focus, and drive. They enable time efficiency, broaden possibilities for advancement, reduce the requirement for instructor presence in the laboratory, and assist in fostering essential skills such as problem-solving and critical thinking. Scientists have found specific characteristics that are essential for an optimal augmented reality (AR) development platform. These elements include user-friendly programming environments, straightforward tools, and functionality that make data collecting, student testing, and social engagement easier. Expanding on previous scholarly research, a study undertaken by Quwaider et al. [9] investigates the behavioral impacts of video games. The results of this study may provide significant perspectives on the possible utilization of augmented reality (AR) in educational settings. Moreover, the study conducted by Cui et al.[10] on the alleviating impact of perceived instructor enthusiasm on boredom in the classroom offers valuable insights into the importance of maintaining students' attention in educational environments. Mann and Robinson [11] analyze the occurrence of tedium in lecture halls and identify factors that impact student attentiveness and involvement. Trow's [12] work provides a contextualized understanding of the issues that arise with the shift from elite to mass higher education. It helps to realize the changing character of educational approaches. The analysis conducted by Breiner et al. [13] about the conceptualization of STEM education aligns with the multidisciplinary characteristics of augmented reality applications. To summarize, Bailey et al. [14] conducted an academic review that highlights the similarities between the educational benefits claimed for physical education and school sport. This emphasizes the various advantages that augmented reality (AR) and other immersive learning experiences can provide in educational environments. Researchers in the field of technological advancement have investigated home automation and propose a novel approach utilizing Brain-Computer Interface technology. Their study, outlined in the publication "Enhancing Home Automation through Brain-Computer Interface Technology," investigates the potential of BCI to enhance and streamline home automation systems. Meanwhile, a group of academics carried out an experiment in the realm of educational technology to assess the efficacy of an e-learning application that utilizes augmented reality (AR). This research employs a comprehensive analysis methodology that incorporates VARK analysis and hybrid pedagogy to examine the impact of AR technology on learning outcomes in schools in Pakistan. Collectively, these works demonstrate the diverse array of methods in which new technology can be employed in the fields of education and home automation. They demonstrate the utilization of technical advancements in several disciplines in contemporary research. Additional methods, such as the system usability scale, have the potential to furnish researchers with more comprehensive insights concerning the usability of a software application [17]. In this manner, additional variables can be investigated. The primary objective of this comprehensive literature review is to present a synthesis of the results obtained from five pivotal studies that examine the intricate relationship between time constraints, learning mechanisms, and technological implementations. A meticulous examination is undertaken by Ee et al. [18] within the framework of online mastery learning to determine the effects of time constraints on the academic performance of postgraduate students. The investigation's results offer valuable insights that can be applied to enhance instructional design methodologies. In order to provide insight into the multifaceted elements that impact the smooth incorporation of technological resources in academic environments, Tank and Manavadaria [19] undertook a study that examined the practical obstacles faced during the integration of Information and Communication Technology (ICT) for the purposes of instruction, learning, and assessment. The study conducted by Mitton [20] examines the temporal obstacles encountered by female teacher researchers operating in Turkey and Canada. This provides insights into the intricacies involved in managing research endeavors while simultaneously fulfilling teaching obligations; consequently, it has ramifications for ongoing professional growth. Jiang et al. [21] propose an innovative framework for software systems that explicitly accounts for temporal constraints. The authors also emphasize advancements in software engineering methodologies. Moreover, Sjøberg et al. [22] examine the software limitations intrinsic to large-scale application systems in their research. They provide significant perspectives on the challenges associated with the development and upkeep of these systems.

II. METHODOLOGY

Within the scope of this study, a comprehensive inquiry into hybrid pedagogy is being carried out. This analysis will focus on the combination of augmented reality (AR)-based learning with traditional teaching approaches. A specially built augmented reality application that is intended to educate users on the complex subject of energy is one of the most important focal points of this investigation. There are four main pedagogical techniques that are included in this research, and each of these approaches offers a different point of view on the incorporation of augmented reality into the learning process:

Traditional Pedagogy:

This acts as a baseline, representing traditional methods of instruction that do not include the use of augmented reality.

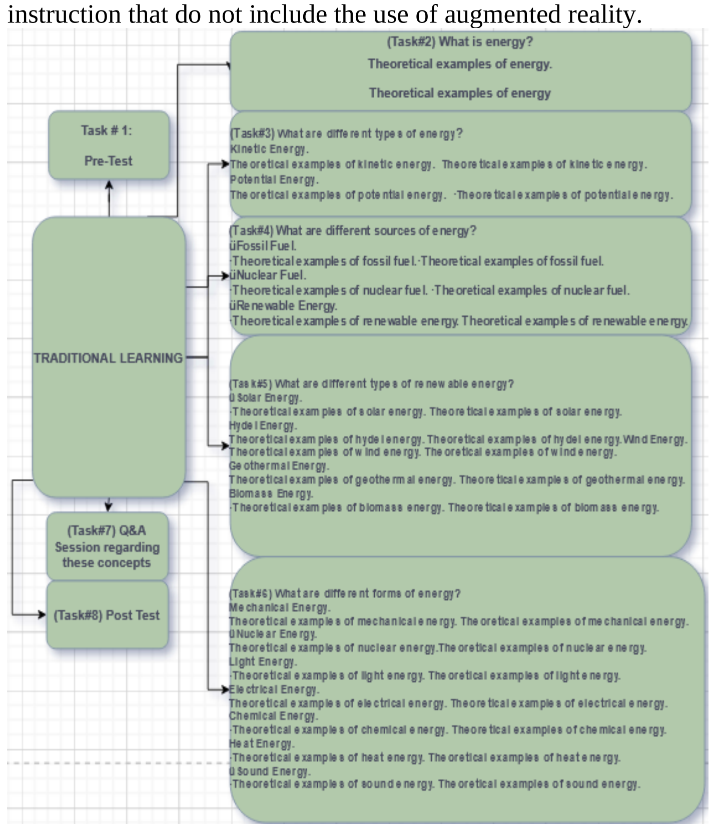

Figure 1 Detailed Representation of First Pedagogy

AR-based E-Learning Pedagogy:

Pedagogy for e-learning that is based on augmented reality involves students interacting with the immersive world of augmented reality, which results in a dynamic and engaging learning experience.

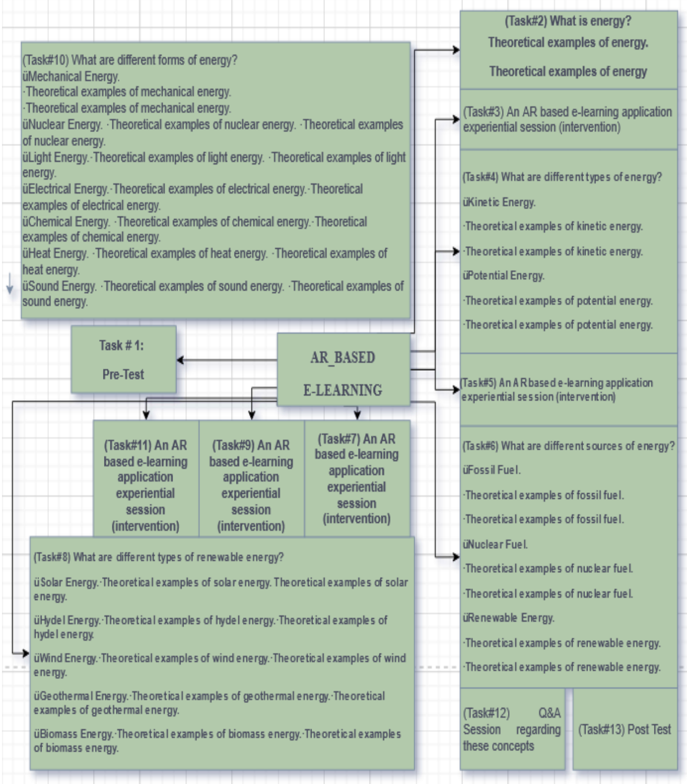

Figure 2 Detailed Representation of Second Pedagogy

AR-based E-Learning Pedagogy with Scaffolding:

This strategy, which is based on the AR-based method, incorporates scaffolding in order to provide learners with additional help and direction as they navigate the augmented environment.

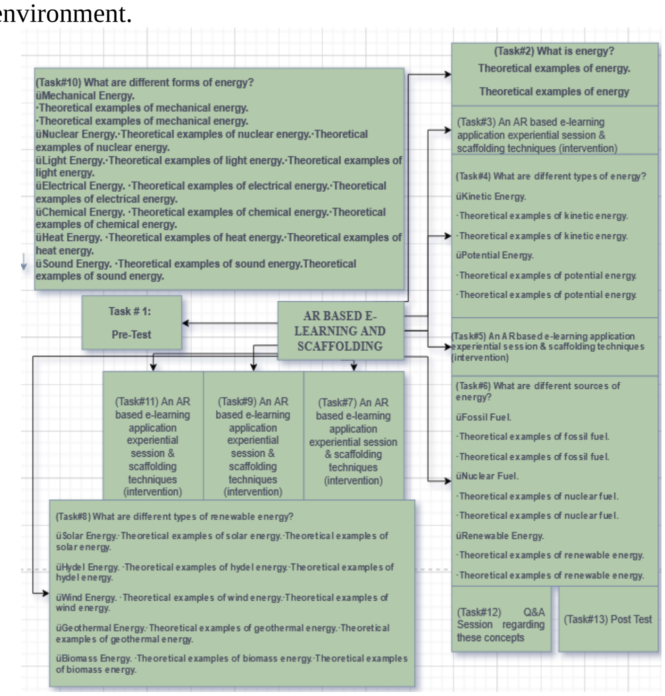

Figure 3 Detailed Representation of Third Pedagogy

AR-based E-Learning Pedagogy with Scaffolding and Gamification:

Scaffolding and Gamification in Augmented Reality-based E-Learning Pedagogy: This technique incorporates aspects that are similar to games into the instructional design in order to improve engagement and interactivity inside the augmented learning environment.

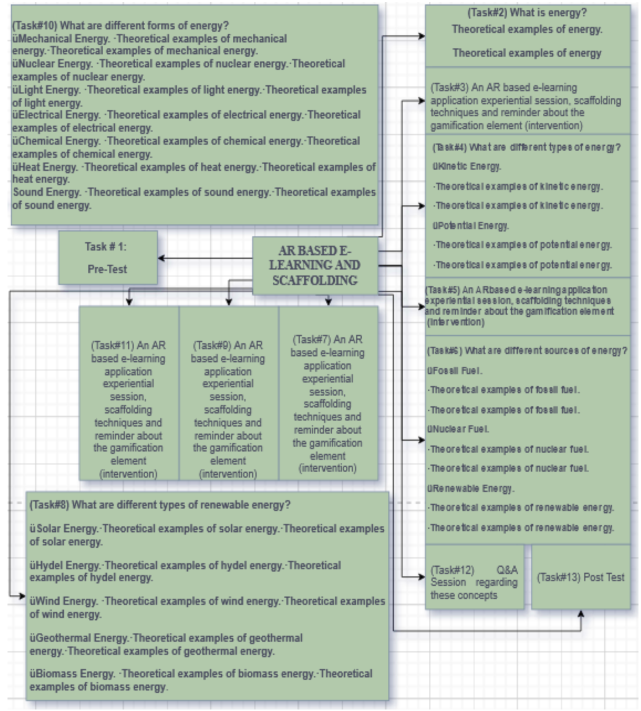

Figure 4 Detailed Representation of Forth Pedagogy

The structure of the menu that is used to depict different types of energy includes buttons that allow users to interact with each type of energy, including nuclear energy, mechanical energy, electrical energy, chemical energy, sound energy, heat energy, and light energy. There are three additional buttons, one of which is a back button that takes the display back to the energy menu, while the other two buttons are reserved for providing definitions and explanations of different types of energy. The animation stage in this menu was developed to illustrate several types of energy in a single scene, such as a fire in a medieval setting with wind blowing. This provides the students with a suitable example, as chemical energy, wind energy, sound energy, light energy, and heat energy are all exhibited and felt in a single shot. At any given moment, the upper right corner of the screen displays the name of the menu directory that the user is now navigating through.

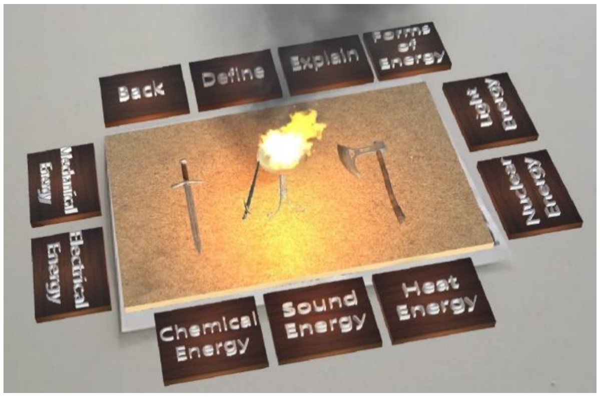

Figure 5 Forms of energy menu in app view

There is a button labeled "define" and another one labeled "explain" on the menu for chemical energy. These buttons are supposed to provide a definition and an explanation of chemical energy, respectively. Other than the ability to return to the kinds of energy menu by using the back button, this menu does not have any linkages to other menus. In the animation, there is a scenario in which food is placed on the table, and it was explained that food contains chemicals and generates energy in the human body. At any given moment, the upper right corner of the screen displays the name of the menu directory that the user is now navigating through.

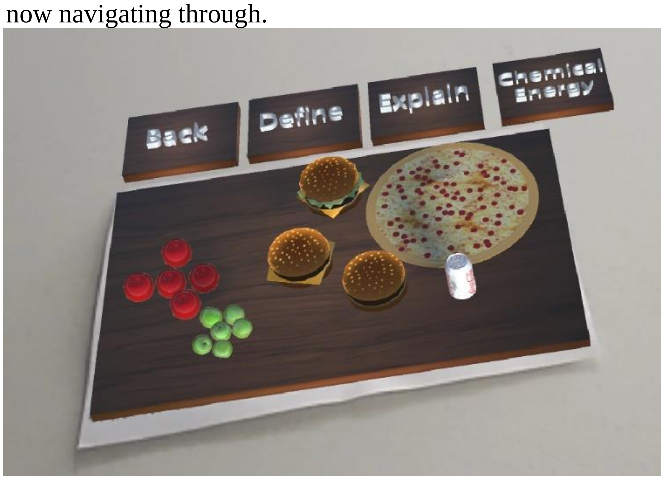

Figure 6 Chemical energy menu in app view

For the purpose of providing a definition and an explanation of mechanical energy, respectively, the arrangement of the menu for mechanical energy is designed to include a button labeled "define" and another labeled "explain." Other than the ability to return to the kinds of energy menu by using the back button, this menu does not have any linkages to other menus. The animation that is displayed in this menu is a representation of a clock that has both an hour hand and a minute handset. That spin around the dial to show how mechanical energy is beneficial to humans in their day-to-day lives, and it is a fantastic example of a practical application that kids can relate to. At any given moment, the upper right corner of the screen displays the name of the menu directory that the user is now navigating through.

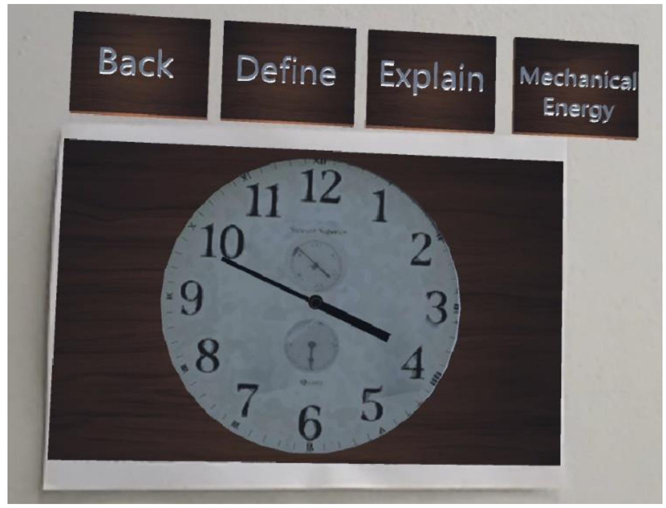

Figure 7 Mechanical energy menu in app

III. RESULTS AND DISCUSSION

The amount of time that is required for each classroom session is referred to as the time restriction. Because of this, the more time that any particular technique of instruction requires, the more inefficient that approach is with regard to time, and consequently, there is a greater time constraint involved. Nevertheless, in order to accomplish this goal, a subject matter expert assigned a specific amount of time to each activity that was a task. The instructor was responsible for carrying out those tasks, and the time that the instructor spent on them was recorded and evaluated to determine how efficiently they were completed.

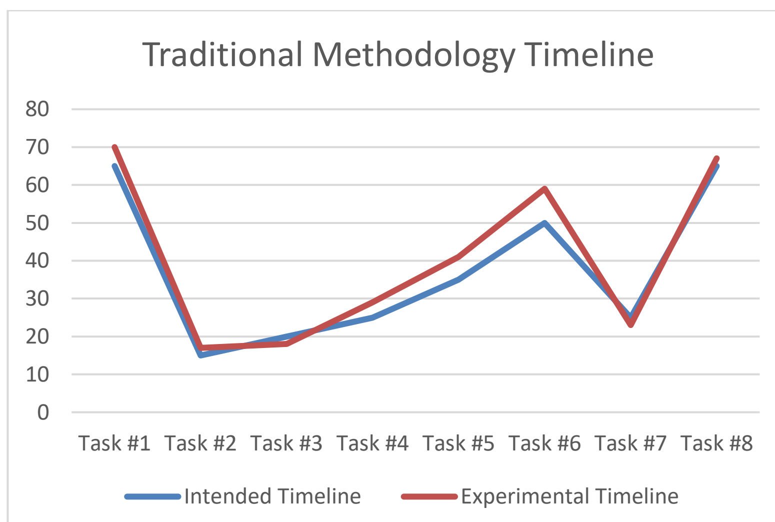

Figure 8 Traditional Classroom Methodology Timeline

The outcomes of the data that is currently available in a regular classroom setting are pretty comparable to what was anticipated prior to the tasks being assigned, and some of the tasks are completed even before the time that was planned for them to be completed.

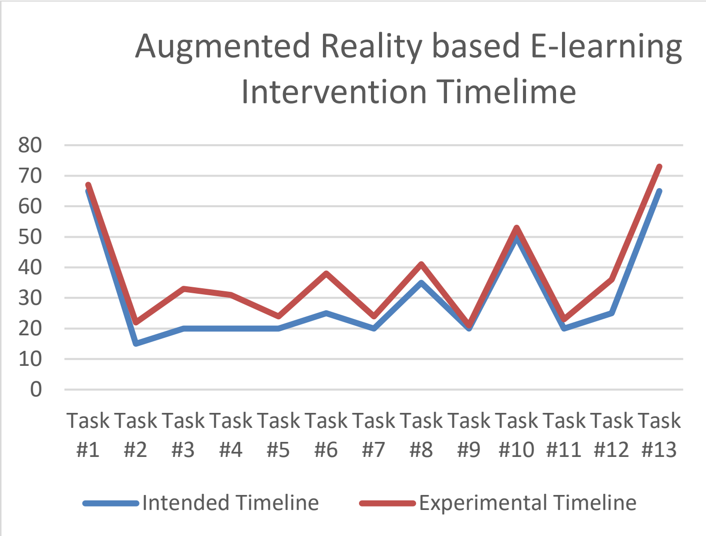

Figure 9 Augmented Reality based E-Learning Methodology Timeline

On the other hand, when the intervention was implemented in the form of an augmented reality-based e-learning application, the temporal variation was far higher than was previously observed. Since the discrepancy between the time that was anticipated and the time that was really spent is greater than that of any other group, this demonstrates that it is considerably more difficult to complete interventions in a timely manner for the very first time.

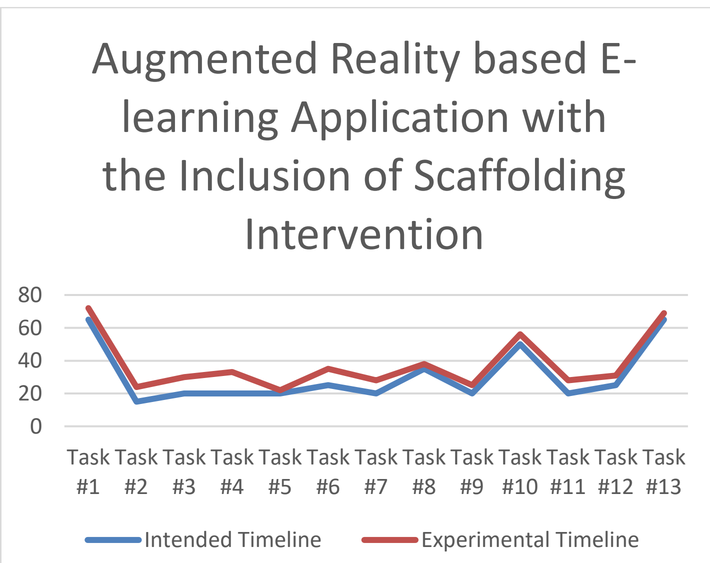

Figure 10 Augmented Reality based E-Learning with Scaffolding

Methodology Timeline

However, in the case of the second experimental group with the intervention of AR based e-learning application with the inclusion of scaffolding.

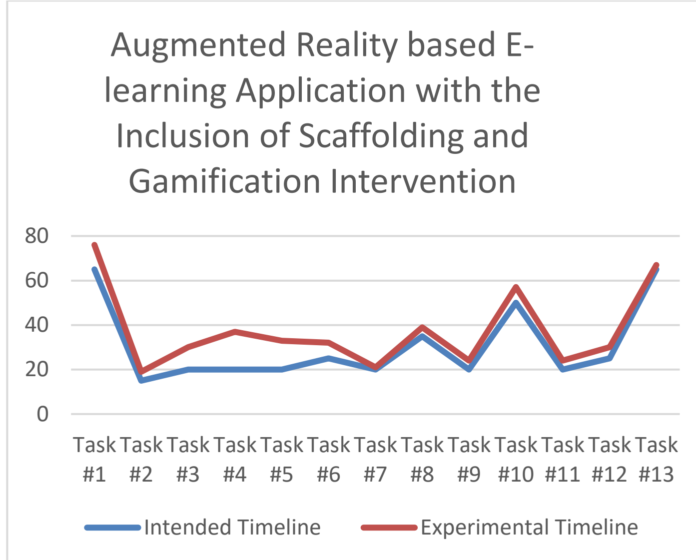

Figure 11 Augmented Reality based E-Learning with Scaffolding and

Gamification Methodology Timeline

The fourth group is the one that has the greatest interventions, which makes it difficult to deliver as an instructor, and the results have diverged correspondingly. Compared to the time that was anticipated, this hybrid pedagogy consumed a considerable amount of additional time.

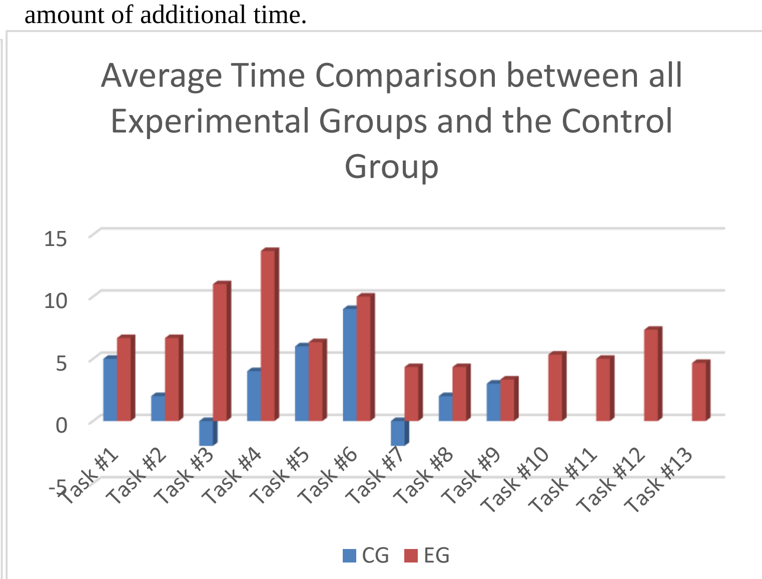

Figure 12 Timeline Average Difference between Experimental Groups and a Control Group

In fig. the average difference between the estimated time that was expected, and the actual time taken is represented. The experimental groups have 4 extra tasks in total but the tasks that are similar in both control group and experimental groups show a drastic shift in them as in the traditional methodology the teachers feel more confident in comparison, and they have the advantage of the experience they have in that exact pedogeological style.

For the eight tasks that were performed by the control group, the time difference between the actual time line and the expected time line was as follows: task 1 took five minutes, task 2 took two minutes, task 3 took two minutes, task 4 took four minutes, task 5 took six minutes, task 6 took nine minutes, task 7 took two minutes, task 8 took two minutes, and task 9 took three minutes. This results in an additional three minutes being spent on each activity on average. However, the time difference between the actual time line and the expected time line for each of the eight tasks in all of the experimental groups combined and averaged was as follows: task 1 = 6.66 minutes, task 2 = 6.66 minutes, task 3 = 11 minutes, task 4 = 13.6 minutes, task 5 = 6.33 minutes, task 6 = 10 minutes, task 7 = 4.33 minutes, task 8 = 4.33 minutes, task 9 = 3.33 minutes, task 10 = 5.33 minutes, task 11 = 5 minutes, task 12 = 7.33 minutes, and task 13 = 4.66 minutes respectively. In addition, the average difference between the experimental groups for each activity was 6.82 minutes, which was a figure that was more than twice as large as the value that was found in the conventional classroom setting. Ultimately, the lack of familiarity with the technology that was utilized in the intervention was one of the most significant issues that contributed to the need for more time. On the other hand, if the instructor used this pedagogy for a longer period of time, they would be able to comprehend the concepts of these augmented reality-based e-learning applications. For this reason, it will always take approximately one month for the instructors to become accustomed to this hybrid pedagogy. However, in the beginning, it will be quite a bit more challenging for both the students and the instructors. Additionally, because this pedagogy includes four additional tasks for every eight tasks, it requires a significantly longer amount of time, which may not be appropriate in many situations. Nevertheless, at this moment, it is nothing more than a hypothesis.

IV. CONCLUSION

The results obtained from analyzing the performance of the control group in comparison to the combined outcomes of all experimental groups provide valuable insights into the complex correlation between time limitations and the incorporation of augmented reality (AR) in educational settings. The average amount of additional time required by the control group for each task was three minutes, suggesting that the impact on conventional learning activities was relatively manageable. Nevertheless, upon analyzing the time disparities among all experimental groups, a significant surge in mean minutes, specifically 6.82 minutes, was detected. The notable disparity, which is greater than twice the magnitude observed in the traditional classroom environment, highlights the difficulties that arise with the implementation of e-learning applications based on augmented reality. Instructors' limited familiarity with the technology was identified as the main cause of the increased time requirements, underscoring the necessity for an approximately one-month transitional period during which instructors could acquire proficiency in utilizing this hybrid pedagogy. While there may be initial difficulties for instructors and students in navigating the learning curve, this study emphasizes the significance of continued exposure to and adjustment to the augmented reality environment. However, the integration of four extra assignments into this pedagogy significantly increases the time investment, necessitating a thoughtful evaluation of its suitability across different educational settings. This research not only offers pragmatic perspectives on the temporal ramifications of augmented reality-enabled e-learning but also establishes a foundation for subsequent inquiries and enhancements of hybrid pedagogical methodologies.

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