Exploring the Effectiveness of Augmented Reality based E-Learning Application on Learning Outcomes in Pakistan: A Study Utilizing VARK Analysis and Hybrid Pedagogy

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Abstract- Traditional instructional methods are becoming increasingly obsolete as the recent Industrial Revolution advances. The abstract nature of several subjects and the linear lecture-based approach have posed challenges for students. The purpose of this study is to compare the learning outcomes and learning styles of two groups of students: the control group and the experimental group. As determined by the T-test analysis of the class learning outcomes, hybrid pedagogy produced superior results. In addition, the VARK analysis revealed that students from both groups utilize the four learning styles of visual, auditory, reading/writing, and kinesthetic to an almost equal extent. The use of multiple learning styles leads to improved outcomes and has a positive effect on the learning outcomes of students. In addition, this is accomplished by combining an Augmented Reality based e-learning application with conventional learning techniques teaching the topic renewable energy sources.

Index Terms- Augmented Reality, E-Learning, Hybrid Pedagogy, VARK Learning Styles

I. INTRODUCTION

Digital interactive applications have assumed a central role in the daily lives of the overwhelming majority of people in modern society, attracting the attention of scholars worldwide. Initially, the academic community focused predominantly on the social aspects of digital interactive applications. However, as the industry progressed, it became clear that these interactive simulations covered a much broader range of topics than just the social domain. Unfortunately, most experts [1] have neglected the cognitive potential of digital interactive applications. Numerous hypotheses exist regarding the benefits of digital interactive applications, but academicians continue to hold divergent opinions. On the one hand, these applications offer advantages such as the enhancement of problem-solving and social skills, but on the other hand, they have disadvantages such as the promotion of anger, aggression, anxiety, and tension. This dichotomy suggests that the negative effects of digital interactive applications are frequently a result of their depiction of violent narrative patterns, with graphics playing an important role in this depiction [2]. The motivation and engagement of educators have a substantial impact on the responsiveness of students in the classroom. Gamification is a viable solution to this problem because it eliminates concerns about students' attention spans, allowing instructors to concentrate on the instructional process [3]. A team of researchers conducted a study involving the distribution of a questionnaire to a large group of students, revealing that 59% of respondents found traditional lectures to be monotonous and uninteresting, while 30% found most, if not all, lectures to be tedious and uninteresting. These statistics demonstrate the urgent need for a radical overhaul of the current educational system [4]. The overemphasis on expanding educational institutions as opposed to cultivating the specific skill sets required for the global job market is one of the most significant challenges faced by developing countries. This disparity is a significant barrier to educational progress in developing countries [5]. The incorporation of STEM (Science, Technology, Engineering, and Mathematics) elements into the curriculum, a concept formally known as "STEM infusion," provides a straightforward solution to this problem. This strategy is advantageous due to its practicability and simplicity of implementation, obviating the need for a comprehensive overhaul of the educational system [6]. It is widely acknowledged by both students and teachers that digital interactive applications are gaining popularity on a global scale, facilitated by the ubiquitous availability of devices and internet access. According to numerous academicians around the globe, digital interactive applications can significantly improve learning effectiveness and cultivate a deeper comprehension of the subject being studied. Many instructors who employ applications as part of their instructional strategy do so as a supplement to more conventional pedagogical techniques [7]. There are no insurmountable impediments to acquiring new skills today. Educators and developers can easily acquire the skills necessary to construct augmented reality-based applications that are closely aligned with the subjects taught in educational settings using software such as Unity. This learning process is facilitated by abundant instruments and pertinent online courses. For educators who are less proficient with technical applications such as Unity, Game Salad can serve as a viable alternative. As students explore these topics, they are likely to acquire confidence, and the outcomes can be genuinely remarkable. Concepts become less abstract, and students acquire a greater degree of control and a more nuanced comprehension of minute details. In both basic and advanced education, the absence of relevant and effective examples has presented a challenge, especially when topics lack real-world applications. The disconnect between instruction and prior knowledge impedes the application of theoretical concepts to real-world examples, which inhibits the learning process. Existing research investigates the positive effects of digital interactive applications on learning. Numerous initiatives and researchers are currently devoted to STEM-based solutions that have the potential to profoundly impact society. This is illustrated by Project Pals, which is intended to facilitate students' learning experiences. The primary goal is to create a personalized learning environment where students can acquire knowledge without the burdens of extensive reading or exam preparation. The central focus is on the student, creating a tangible virtual repository of their concepts and assisting them with organization and peer collaboration. While some of these applications explicitly target STEM education, others, such as online gaming platforms that have a significant impact on students' cognitive development, are available for educators to investigate. A profusion of libraries exists in this discipline, making the selection of suitable titles difficult [8]. Researchers in Vietnam attempted to improve vocabulary acquisition after discovering that their pupils lacked fundamental learning skills and relied solely on their instructors' explanations. The incorporation of video games into the educational process increased student engagement and led to remarkable gains in academic performance. Intriguingly, it also improved teacher performance as a result of their acquiring new knowledge [9]. The central premise is that students learn more effectively and retain information for longer when they are provided with pleasant experiences. Experience is an essential element of the learning process. Consequently, it is essential to comprehend how students perceive information, as it molds their perspective of their surroundings. A group of researchers has proposed a novel technique for identifying perceptual patterns. This was accomplished by observing computer engineering students as they solved puzzles and drawing conclusions based on the collected data. 47 computer engineering majors participated in the experiment, and the results were determined to be 85 percent accurate. The researchers were confident that video games could be used to analyze the perceptual patterns of pupils [10]. Scholars from Malaysia conducted a study on the impact of video games in the context of difficult subjects such as programming. Twenty-four distinct measures revealed that playing video games substantially improved students' motivation, attitudes, cognitive development, interaction, and expectations regarding the subject. This resulted in increased student enthusiasm for programming education, and their positive attitudes were infectious. Additionally, it improved their subject knowledge [11]. Even though each of the applications and studies is significant and valuable, very few of them advocate for a specific learning strategy. The concern stems from the fact that these applications have room for development but fall short of being completely customized. Thus, determining the most effective method becomes one of the foremost concerns of researchers. Augmented Reality (AR) has emerged as a transformative technology in the realm of education, providing innovative approaches to enhance learning experiences. Bint-E-Asim [12] looked into how robotic kits could be used to bring live STEM subjects into online classrooms and make learning more fun. Hadi [13] investigated working strategies for beginners in a different study, which shed light on good ways to be successful in this career field. Lashari [14] used Universal Design for Learning to look into how custom-built video game simulators affected learning in Pakistan. Samad Danish [15] also set up a Smart Aquarium System that can be monitored and controlled from afar using the Internet of Things. This shows how technology can be used in a variety of teaching settings. Furthermore, Danish did a study that compared how traditional teaching methods and virtual reality affected student performance in the classroom [16]. All these studies help us learn more about the role of augmented reality in education, highlighting how it has the ability to completely change the way we learn. Looking into how to improve the multi-objective parameters of driver-based electromagnetic sheet metal making of SS304 using AA6061-T6 driver material. The study looks into optimization strategies for the electromagnetic sheet metal forming process. It gives useful information for making forming processes more accurate and efficient. Also, the results could be used in education, especially if they were shown in augmented reality, which would make learning more useful and engaging [17].

II. METHODOLOGY

The objective of this work is to create an innovative augmented reality (AR)-based electronic learning application specifically designed to teach abstract ideas related to renewable energy. The aim is to implement an array of applications and tools, such as Unity, a flexible and cost-free Augmented reality-based e learning software which allows immersive and interactive learning experiences, TinkerCad to create 3D models for the application, Visual Studio Editor to code C# efficiently, and Photoshop to enhance and generate textures. The main goal is to evaluate the efficacy of augmented reality (AR) in strengthening students' morale and comprehension of intricate abstract subjects in comparison to conventional learning approaches. To accomplish this, an augmented reality (AR) simulation that was designed with the concept of renewable energy in particular was intuitive. In contrast to conventional methods, the augmented reality (AR) application offers a streamlined yet accurate learning environment, thereby alleviating the technical obstacles encountered in comparable applications. The fundamental idea pertains to a captivating, augmented reality encounter in which users engage with renewable energy principles, including wind and solar power, via intuitive gestures. Users have the ability to manipulate solar panels and wind turbines within the augmented reality environment, thereby modifying their orientations and comprehending the resulting effects on energy production. The primary objective is to create an engaging and user-friendly learning environment that facilitates the understanding of renewable energy principles. The design of the application prioritizes the reduction of technical intricacies, enabling users to investigate and acquire knowledge regarding renewable energy via augmented reality (AR) interactions. This facilitates a more profound comprehension without necessitating substantial technical expertise.

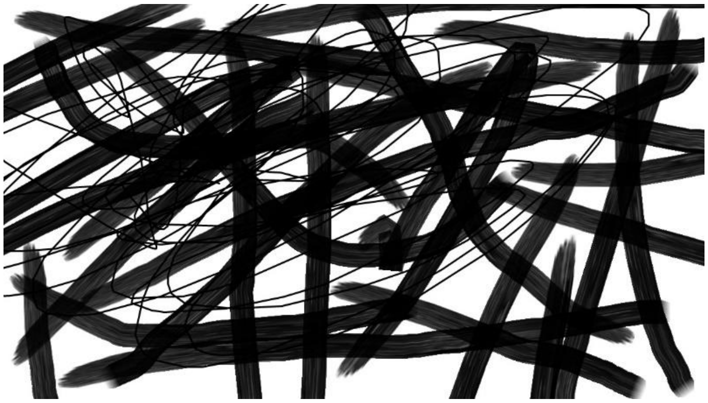

Fig. 1. Marker Recognized by AR Application

The aim of the augmented reality (AR) e-learning application for renewable energy is to provide users with a comprehensive and enlightening encounter while they investigate the fundamental concepts and practical implementations of these sources. Users are encouraged to interact with renewable energy concepts through the manipulation of virtual elements present in their physical surroundings using the augmented reality application.

Fig. 2. Wind Farm in AR Application

Users can investigate intricacies of renewable energy, including solar panels, wind turbines, and hydroelectric generators, by manipulating the orientation and placement of augmented reality (AR) objects using intuitive gestures.

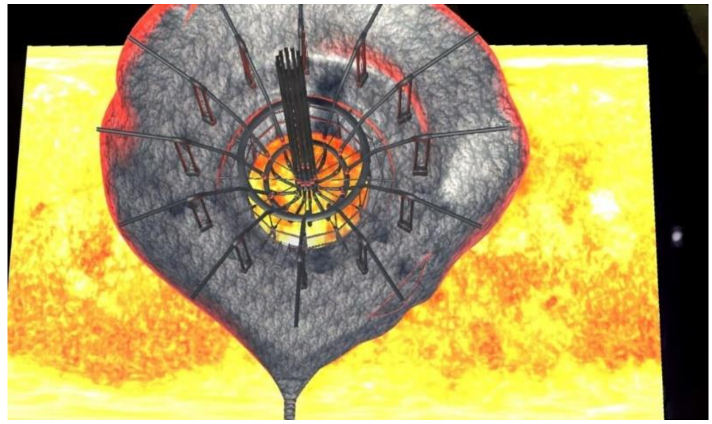

Fig. 3. Example of Geothermal Energy in AR Application

Users are tasked with comprehending the most efficient arrangement and configuration of these energy sources via the application. Furthermore, users have the ability to modify environmental variables, including wind speed and radiation intensity, in order to analyze their influence on energy generation.

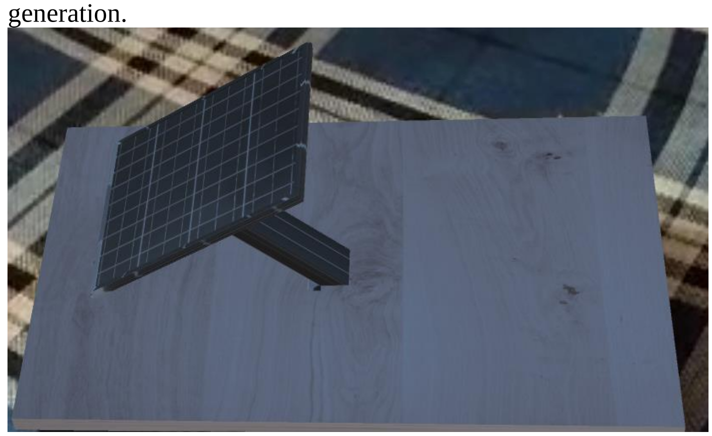

Fig. 4. Solar pannel in AR Application

As users advance, the complexities of the challenges increase, incorporating elements such as variations in climate and geographical terrain. The objective of this dynamic and interactive methodology is to augment users' comprehension of the principles and pragmatic implementations of renewable energy. To ensure uniformity, two groups of fifty eleventh-grade students were selected at random for this experiment. A control group is comprised of individuals who keep to conventional learning methodologies, whereas the experimental group is engaged in a hybrid pedagogical approach. The experimental group enhances the learning experience by combining conventional methods with the AR-based e-learning application. This methodology guarantees compliance with traditional pedagogical methods while incorporating the cutting-edge augmented reality application to cultivate a more profound comprehension of renewable energy principles. The objective of the experiment is to evaluate the collective academic achievement of the class and perform a VARK analysis in order to gain a thorough comprehension of the various learning styles exhibited by the students and how these styles influence their academic results. The experiment's outcomes provide significant insights into the diverse learning profiles of students and their academic achievement. The assessment of class performance consists of pre- and post-tests that comprise inquiries pertaining to renewable energy principles, such as the most efficient placement of energy sources and computations for energy generation. In addition, feedback forms are utilized to collect data for a VARK analysis regarding the learning preferences of students in the following areas: visual, auditory, reading/writing, and kinesthetic. The descriptive analysis, which consists of fifteen inquiries, offers a comprehensive assessment of both the course outcome and individual learning profiles. This aids in developing a profound comprehension of the efficacy of the augmented reality (AR) e-learning application as it pertains to the instruction of renewable energy concepts.

III. Results

The VARK analysis of 50 students in the control group is represented in a pie chart in Figure 9. It is observed that 27 percent of the students in the control group rely on the visual style of learning, 22 percent rely on auditory learning, 22 percent rely on reading/writing learning, and 29 percent of the students rely on kinesthetic learning. In contrast, the VARK analysis of the experimental group, represented in Figure 10, shows that 24 percent of the students rely on kinesthetic learning, 26 percent rely on visual learning, 27 percent rely on auditory learning, and 23 percent rely on reading/writing learning.

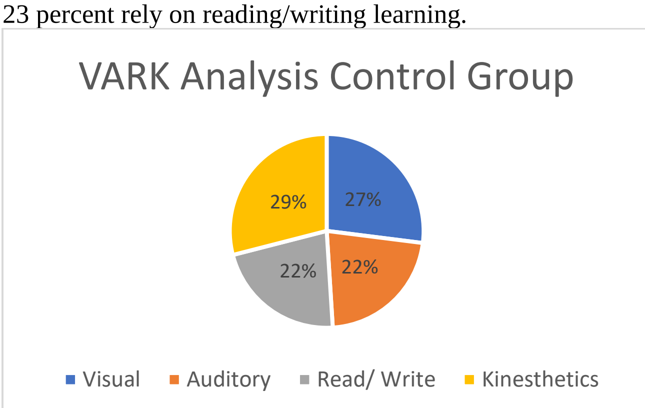

Fig. 5. VARK Analysis Control Group

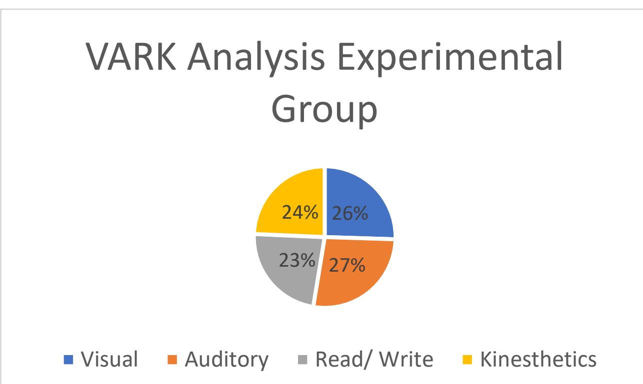

Fig. 6. VARK Analysis Experimental Group

The class outcome is quantified using pre and post-tests of all students in both the experimental and control groups, as represented in Figure 5 and Figure 6. The pre-test serves as a measure of the students' base knowledge, while the post-test represents the results of the students after the intervention is completed. These figures allow for a comparison of the students' performance before and after the intervention, providing insight into the effectiveness of the teaching method employed.

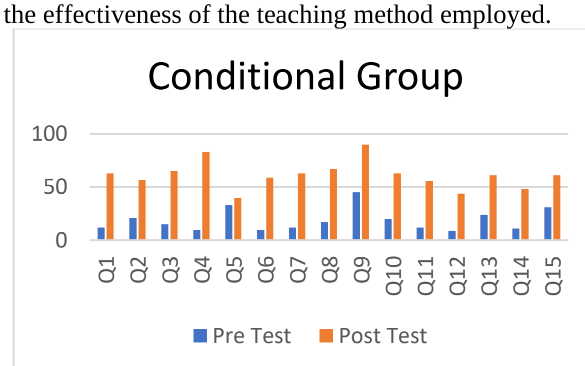

Fig. 7. Pretest and Post Test Class Performance Control Group

The average of the pre-test results for the control group is 18.8 percent, while the average of the pre-test results for the experimental group is 19.86 percent. The average of the post-test results for the control group is 61.33 percent, while the average of the post-test results for the experimental group is 74.06 percent. These figures demonstrate the performance of the students in both groups, prior to and following the intervention, respectively.

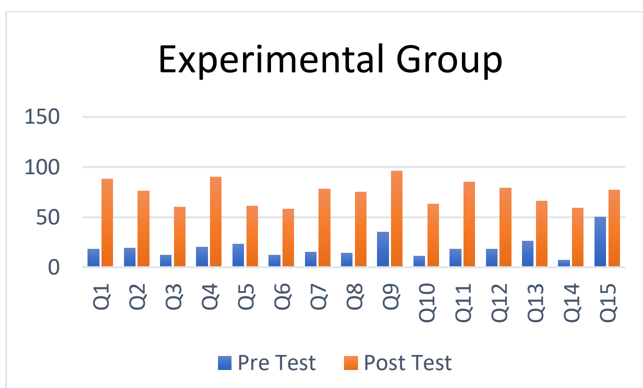

Fig. 8. Pretest and Post Test Class Performance Experimental Group

Figures 7 and 8 present the improvement in pre-test and post-test results in the control group and experimental group respectively. These figures provide a visual representation of the change in performance of the students in both groups, as a result of the intervention.

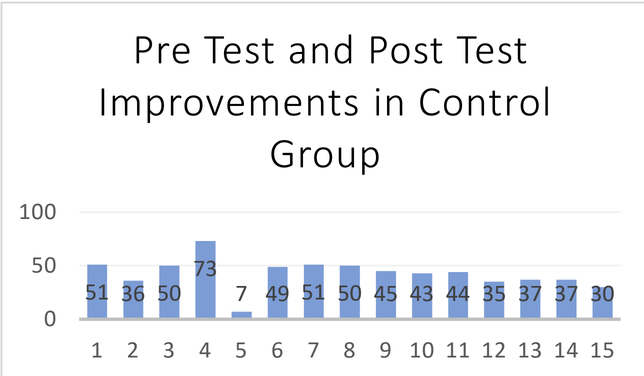

Fig. 9. Improvement in Class Performance in Control Group

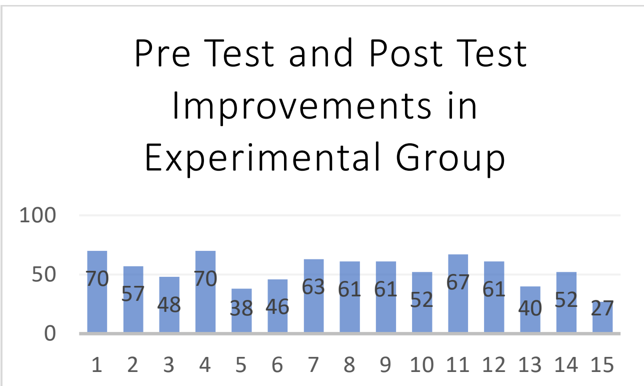

Fig. 10. Improvement in Class Performance in Experimental Group

The group statistics for the pre-test analysis of both the control and experimental groups are represented in Figure 9. A total of 50 students attempted all questions in the pre-test. However, the t-test results, represented in Figure 10, indicate that there is no significant difference in the pre-test results of both the experimental and control groups. The significance level (Sig.) of 2-tailed values is 0.785, which is greater than 0.05, thus supporting the null hypothesis that there is no significant difference between the two groups in their pre-test results.

T-Test

[DataSet1]

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Score	1	15	18.8000	10.48264	2.70661
	2	15	19.8667	10.76281	2.77895

Fig. 11. Pretest Results Group Statistics

		Levene's Test for Equality of Variances	
		F	Sig.
Score	Equal variances assumed	.117	.735
	Equal variances not assumed		

Fig. 12. Indipendant T Test for Pretests of both Groups i

Independent Samples Test

t-test for Equality of Means						
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
-.275	28	.785	-1.06667	3.87921	-9.01286	6.87953
-.275	27.981	.785	-1.06667	3.87921	-9.01311	6.87978

Fig. 13. Indipendant T Test for Pretests of both Groups ii

However, Figure 12 and Figure 13 present the post-test result statistics of both the experimental and control groups. The t-test results of the control and experimental groups are provided in Figure 13. The significance level (Sig.) of 2-tailed values is 0.01, which is less than 0.05, indicating a significant difference in the post-test results between the two groups. This result disproves the null hypothesis of no significant difference between the post-test results of the control and experimental groups.

T-Test

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Score	1	15	61.3333	12.90441	3.33190
	2	15	74.0667	12.37201	3.19444

Fig. 14. Posttest Results Group Statistics

		Levene's Test for Equality of Variances	
		F	Sig.
Score	Equal variances assumed	.344	.562
	Equal variances not assumed		

Fig. 15. Indipendant T Test for Posttest of both Groups ii

Independent Samples Test

t-test for Equality of Means						
					95% Confidence Interval of the Difference	
t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
-2.759	28	.010	-12.73333	4.61585	-22.18846	-3.27820
-2.759	27.950	.010	-12.73333	4.61585	-22.18922	-3.27745

Fig. 16. Indipendant T Test for Posttest of both Groups ii

The t-test results of the post-test indicate a significant difference between the control and experimental groups. This suggests that one of the groups performed better on the post-test. To determine which group performed better, the mean or average of the post-test results for each group is calculated. The mean of the post-test results for the control group is 61.33, and the mean of the post-test results for the experimental group is 74.06. This indicates that the experimental group performed better on the post-test.

IV. CONCLUSION

Learning is a fundamental aspect of human development, yet it is also complex. The higher secondary schooling system in Pakistan primarily employs a chalk-talk learning pedagogy and heavily relies on reading and writing. This results in a pedagogy that is not inclusive enough to engage students of all learning styles and does not adhere to the principles of universal design for learning. The incorporation of visual, auditory, and kinesthetic elements into traditional learning methodology provides a unique perspective on the diversity of pedagogy. The post-test results obtained from the experimental and control groups indicate a significant improvement in the performance of both groups. The uniformity of the control and experimental groups is validated through a t-test analysis of the pre-test results. The students involved in this research demonstrate a clear dependence on multiple learning styles, with a majority of students displaying an almost equal dependence on visual, auditory, reading/writing and kinesthetic learning styles. This suggests that traditional learning pedagogy, with its strict focus on chalk-talk based reading and writing and auditory learning styles, does not provide an optimal learning experience for students. However, hybrid pedagogy, which encompasses all learning styles, yields better results.

V. FUTURE WORK

Furthermore, a study can also be carried out in future regarding the instructional design of hybrid pedagogies in learning environment.

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