Evaluating the User Experience of an Augmented Reality E-Learning Application for the Chapter on Work and Energy using the System Usability Scale

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Abstract- This study provides a thorough assessment of the user experience of an augmented reality (AR) e-learning application specifically developed for the 9th-grade physics chapter on Work and Energy. The study employs an experimental methodology and applies the System Usability Scale (SUS) to examine several aspects of usability and user perception. The findings, presented using pie charts and in-depth talks, demonstrate a favorable student attitude towards the AR application, suggesting a high level of agreement about its frequency of usage, user-friendliness, and integration of features. A significant majority strongly disagreed with the view of the system being complex, the requirement for technical assistance, and inconsistency, hence reaffirming the user-friendly characteristics of the program. The research highlights specific areas that can be enhanced, proposing future efforts in refining the content and features, incorporating adaptive learning methodologies, and investigating extended reality technology. Furthermore, it is advisable to take into account accessibility, incorporate collaborative learning functionalities, and provide instruction for educators in order to maximize the application's effectiveness in various educational environments. The findings provide useful insights for further enhancing and refining AR e-learning apps, hence promoting a more immersive and efficient teaching experience for 9th-grade physics students.

Index Terms- Augmented Reality E-Learning, User Experience Evaluation, Instructional Design, System Usability Scale, Educational Technology Assessment

I. INTRODUCTION

Although education is not new, there are new practices. Many years ago, many people were not lucky enough to have an invention that would benefit their education. Today, holistic innovations and special education innovations are being developed very quickly and used in educational and recreational schools. PCs, mobile phones, smart boards, audio recordings, audiovisual applications, educational games and learning platforms, entertainment, augmented reality, Web and Web 2.0 applications are just a few of the new models already made by teachers and students in education. Researchers are looking into how augmented reality (AR) may be used in the classroom. AR makes it possible to incorporate virtual things into actual settings, enabling in-the-moment communication. Research on the effects and consequences of augmented reality (AR) in education is, nevertheless, lacking. Because augmented reality can now be used on mobile devices without the need for specialized equipment, its accessibility has risen. Mobile AR applications in education have increased because of this. We still need more research to completely understand how AR can boost students' academic achievement and motivation to learn. A University of Cape Town study investigated how an augmented reality smartphone application affected undergraduate health science students' enthusiasm to learn. Examining variables including attention, relevance, confidence, and satisfaction, the study sought to quantify variations in students' learning motivation when utilizing the augmented reality app. The remainder of the paper outlines the study's background, theoretical framework, methods, conclusions, and ramifications. It also suggests areas for further investigation [1]. Technology has been incorporated into education and the results have shown a positive impact on education. Integration of technology also provides opportunities to improve student learning and engagement. Augmented reality (AR) is a new technology that can be used in education. There is a lot of research on AR but very little research on education [2]. The aim of the current project is to examine the prevalence of AR technology and teachers' awareness of the need for regular training, the process of creating 3D models, and the possibilities of teachers and students creating AR applications in the school environment. Teacher education is important because teachers in many professions look at problems from different perspectives, have long-term, diverse experience with education, and can control events that are initially unexpected [3]. Nowadays, there are new innovations in augmented reality in school education, and special tests have shown that educational results can be very good. In Greece, augmented reality is rarely used in education. Its most common areas of use include its use in open areas of archaeological importance or indoors and in new parks. Therefore, in Greek reality, the use of continuous reality in the classroom at all and its application to new knowledge was a borderline pursuit. The current research aims to fill these two gaps and add further analysis of its educational value. The solutions behind its use may provide another part of the application of reality in the teaching cycle and encourage many researchers to investigate its educational benefits not only for IT education in secondary education, but also for other subjects and

levels of teaching, and finally presentation. offers the latest innovations for professionals and encourages them to start using it more often in training. The field of education has gone through significant changes since the inception of technological advancements. Although traditional educational practices have persisted, modern approaches have implemented a wide range of tools and methodologies to accommodate various learning requirements. Augmented reality (AR), computers, smartphones, smart boards, audio-visual applications, and educational games have all become essential elements of the contemporary educational toolkit. Augmented reality has received significant interest due to its capacity to transform learning experiences through the seamless integration of virtual components into physical environments, thereby enabling interactive and dynamic participation. In spite of the swift incorporation of augmented reality (AR) into diverse educational spheres, there is still a lack of comprehensive research concerning its influence on student satisfaction, specifically as it pertains to e-learning applications. As scholars explore the potential applications of augmented reality (AR) in educational settings, there arises an increasing imperative to evaluate its efficacy in augmenting students' eagerness to learn. It is worth noting that the dynamic nature of educational innovations is underscored by the investigations of Abdul Hayee Baig regarding freelancing strategies for novices [5] and some did work regarding interactive STEM in online education [4].In addition, the investigation conducted by researchers regarding the effects of bespoke video game simulators on learning [6] and the deployment of a Smart Aquarium System via the Internet of Things by HITEC University students. [7] provide insights into the wide range of technological applications in the field of education. The comparative study conducted by computer scientists. [8] that assesses the impact of augmented reality on class performance in comparison to traditional methods provides significant contributions to the ongoing dialogue regarding the effectiveness of AR in educational environments. The present study seeks to expand upon this groundwork by examining the degree of contentment expressed by students who utilize an augmented reality (AR) e-learning application that is centered on a physics topic for ninth graders. By emulating the research, we aim to address knowledge voids in the current body of knowledge regarding the prevalence of augmented reality (AR) technology, the level of awareness among educators regarding it, and the possibility of collaborative development of AR applications within educational settings. In the pursuit of conducting an in-depth examination of the educational environment in Greece, where augmented reality remains underutilized, our objective is to offer a thorough evaluation of its educational merit that surpasses its traditional uses. The incorporation of augmented reality into the field of education presents a potentially fruitful avenue for enriching the learning process. The objective of this research is to make a scholarly contribution to the current dialogue surrounding the educational advantages of augmented reality (AR). The findings will have implications not only for IT education, but also for a wide range of subjects and instructional levels. By embracing an interdisciplinary framework, our objective is to foster additional investigation and application of augmented reality, thereby motivating scholars and practitioners to exploit its capabilities in order to enhance the educational experience. AR can be considered a hybrid technology that includes multiple realities because the technology involves virtual objects in the user's real environment, resulting in interaction with virtual content. In the case of mobile AR, the technology involves adding digital content to the real world through a smartphone camera. Examples of mobile AR applications include Pokémon GO, a mobile AR game that allows users to catch various Pokémon in their area, and AR GPS Driving/Walking Navigation, which provides an AR-powered navigation system. Virtual reality differs from AR because in virtual reality the real world is closed, and users enter the digital world using a headset such as Oculus Rift or Samsung Gear VR. The value of virtuality in this world actually determines the type of technology needed to support AR, as different display and tracking technologies provide different levels of immersion. An example of advanced AR is the Star Wars Jedi Challenges mobile app, which requires users to use headsets. This study tested the impact of the Anatomy 4D mobile app on the promotion of health students at UCT. Augmented Reality (AR) offers a distinctive capability to create immersive and composite learning environments through the seamless integration of virtual and physical components. AR technology in the field of education serves to enhance students' understanding of complex subjects by providing access to scientific scenarios that might otherwise be unattainable, including interactions involving specific substances. Although this is possible, the effective integration of augmented reality (AR) into the classroom requires considerable exertion, as pupils must navigate through immense amounts of data and a variety of technological tools in order to complete complex assignments. Students' motivation is significantly influenced by the efficacy of learning strategies; empirical evidence suggests that augmented reality (AR) has the potential to augment motivation levels within the realm of science education. The motivational design framework known as the Interest, Values, Beliefs, and Interests (ARCS) model provides a structure for understanding the impact of augmented reality (AR) technology on the motivation of students to learn. The correlation between levels of trust and support emphasizes the criticality of developing courses that enable students to assess their own progress. Moreover, scholarly investigations, purposeful surveys, and research applications all support the claim that augmented reality (AR) applications improve student achievement, concentration, and motivation. They facilitate time savings, expand opportunities for progress, diminish the need for instructor presence in the laboratory, and aid in the cultivation of critical abilities including problem-solving and critical thinking. Researchers have identified certain features that are crucial for an ideal augmented reality (AR) development platform. These features encompass intuitive programming environments, intuitive tools, and functionalities that facilitate data collection, student testing, and social interaction. Building upon prior scholarly investigations, a study conducted by Quwaider et al. [9] examines the behavioral effects of video games. The findings of this research may offer valuable insights into the potential engagement of augmented reality (AR) in educational environments. Furthermore, the research conducted by Cui et al. [10] regarding the mitigating influence of perceived teacher enthusiasm on tedium in the classroom provides insights into the significance of sustaining students' interest in educational

settings. Mann and Robinson [11] examine the phenomenon of tedium in lecture halls and identify variables that influence student attentiveness and engagement. The challenges associated with the transition from elite to mass higher education are contextualized in Trow's [12] work, which aids in comprehending the dynamic nature of educational methodologies. The discussion by Breiner et al. [13] regarding STEM education conceptions is consistent with the interdisciplinary nature of augmented reality applications. In conclusion, the academic review conducted by Bailey et al. [14] draws parallels between the educational benefits asserted for physical education and school sport, thereby emphasizing the diverse advantages that augmented reality (AR) and other immersive learning experiences can impart in educational settings. In the field of technological progress, researchers [15] looked into home automation and suggest a new way to do things by using Brain-Computer Interface (BCI) technology. Their research, which is described in the paper "Enhancing Home Automation through Brain-Computer Interface Technology," looks into how BCI could be used to improve and ease home automation systems. In the meantime some researchers conducted an experiment in the field of educational technology by testing how well an augmented reality (AR)-based e-learning app works. In this paper they used a full analysis framework that includes VARK analysis and hybrid pedagogy to look at how AR technology affects learning outcomes in Pakistani schools. Together, these works show the wide range of ways that new technologies can be used in education and home automation. They show how technological advances are used across many fields in modern study.

II. METHODOLOGY

The primary objective of this research is to carry out an in-depth analysis of the user experience that is linked with an augmented reality (AR) e-learning application that was developed specifically for the purpose of teaching the ninth-grade physics chapter on Work and Energy. In the following sections, we will provide a comprehensive and complete overview of the research methodology by providing additional information on the research design, application development, pilot testing, participant selection, procedural details, data collecting, analysis methodologies, ethical issues, and potential constraints. The user experience of the augmented reality e-learning application was evaluated using a design that was considered to be quasi-experimental. The use of this architecture makes it possible to investigate the effects of the augmented reality application without resorting to random assignment. Taking into consideration the educational setting and the requirement for practical insights, a design that is quasi-experimental is considered to be appropriate. Development of the augmented reality application was carried out with great care, with a strong emphasis placed on instructional design concepts. The accuracy, relevance, and pedagogical soundness of the content were all established through the process of collaboration with subject matter experts.

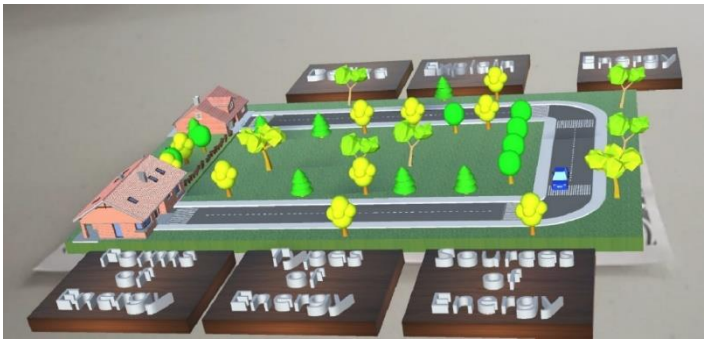

Figure 1 Energy menu in app view

To improve the quality of the learning experience as a whole, the development process involved the introduction of interactive features, multimedia components, and engagement tactics. An initial pilot test was carried out with a limited number of students in order to uncover any potential technical flaws, content gaps, and usability concerns that may have been present prior to the formal review. The purpose of the iterative refinement process, which was based on the feedback received from pilots, was to improve the functioning of the application, solve any challenging situations that were not anticipated, and improve the overall user experience. A total of 28 ninth-grade students were included in the participant pool. These individuals were purposefully chosen to represent a wide variety of academic backgrounds and technological capabilities of the participants. The external validity of the study is improved as a result of this planned diversity in participant characteristics, which also makes it possible to conduct a more systematic investigation into the usefulness of the augmented reality application across a variety of demographics. The augmented reality e-learning application was presented to the participants as soon as they were recruited. During a brief orientation session, they were made acquainted with the many functionalities that the application offered. Following that, participants made their own independent use of the application in order to replicate a learning environment that is similar to the real world. The documentation of qualitative observations and the systematic monitoring of participant interactions guaranteed that a nuanced understanding of user engagement and potential difficulties was achieved. For the purpose of determining how user-friendly the augmented reality application was, the System Usability Scale (SUS) was utilized as the primary quantitative instrument. The SUS questionnaire, which was given to users immediately after they had engaged with the program, was designed to collect quantitative data about the application's usability. SUS scores were supplemented with demographic information, and open-ended questions were used to gather qualitative input regarding the user experience. Both of these methods were applied to collect information.

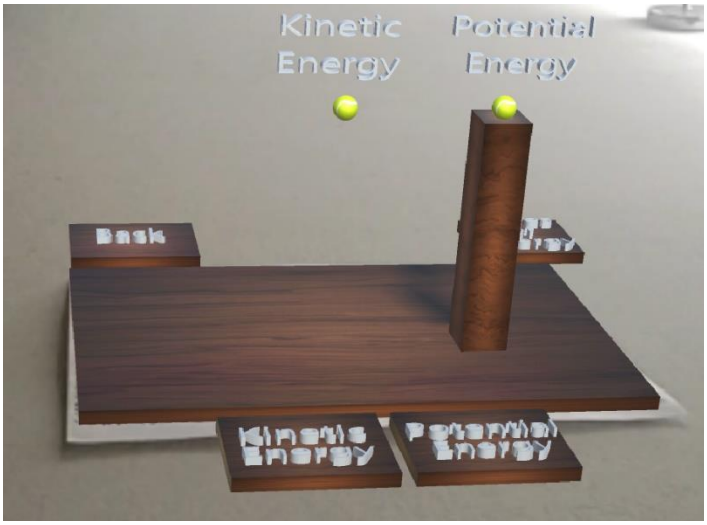

Figure 2 Types of energy menu

The determination of an overall usability score for the augmented reality application was made easier by the accumulation of separate SUS values. The interpretation and comparison of usability scores were carried out with the use of statistical approaches, which included descriptive statistics and inferential analysis. The augmented reality application was subjected to a thorough content analysis, which was performed on qualitative feedback in order to identify specific strengths and areas that required improvement. Conduct that adhered to ethical standards was of the utmost importance throughout the whole research procedure. Conscientious efforts were made to gain informed consent from both the participants and their guardians, providing them with information regarding the objectives, methods, and possible dangers of the study. The anonymity and confidentiality of the participants were protected by the use of measures, and the research was conducted in a manner that was in strict accordance with ethical rules and standards. Recognizing the inherent limitations of the study is absolutely necessary in order to arrive at an interpretation of the findings that is both transparent and correct. Some of the potential limitations include, but are not limited to, limitations on the sample size, the possibility of bias in the self-reporting of participants, and the dynamic nature of technology, which may have an effect on the AR application's capacity to maintain its efficacy over time. The evaluation of the user experience of an augmented reality (AR) e-learning application specifically designed for the ninth-grade physics chapter on work and energy is a method that is rigorous. The robustness and validity of the study are contributions that are made by the thorough examination of each step in the research process. These contributions provide significant insights that may be used for the improvement and future deployment of educational augmented reality applications.

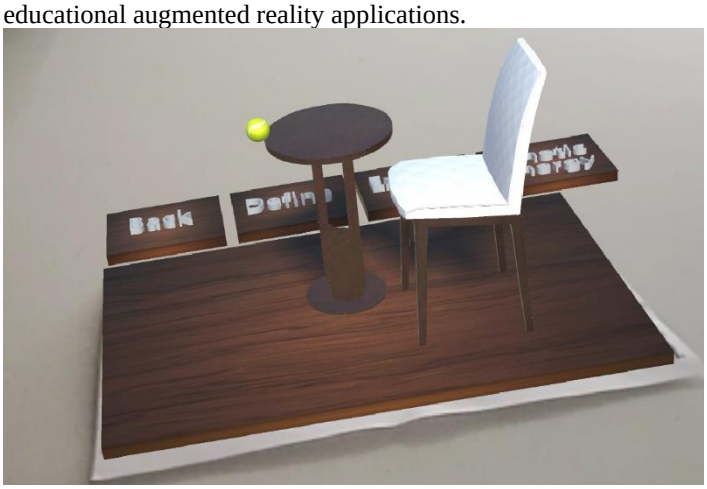

Figure 3 Kinetic energy menu in app view

In figure 1 the layout of the first menu is shown called energy is basically the main menu and it also represents the energy menu, so the design had to incorporate the menu aspect as well as the definition and explanation of energy. This menu leads to types, forms and sources of energy as well as it can explain and define the topic at hand i.e., energy. In the animation part the plan was to explain how a car possesses energy while driving on a road. The name of the menu directory the user is in at a given point is written in the upper right corner. In Figure 2 the layout for types of energy is designed to have a back button that leads back to the energy menu, a kinetic energy button and a potential energy button. The animation of this menu represents a kinetic and potential energy example by displaying a ball that is higher than the ground and a ball falling to show the difference and is further elaborated in the kinetic and potential energy menu. The name of the menu directory the user is in at a given point is written in the upper right corner. In Figure 3 The layout of kinetic energy menu is designed to have a define and an explain button for definition and explanation of kinetic energy respectively. This menu does not have any links to other menus other than going back to the types of energy menu using the back button. The animation in this menu is designed to have a ball falling off a table and the explanation how it is linked to kinetic energy. The name of the menu directory the user is in at a given point is written in the upper right corner which indicates which menu the user is in.

III. Results and Discussion

In figure 4 insightful information regarding the students' perceived frequency of usage of the augmented reality (AR) e-learning application can be gleaned from the responses to this particular SUS question. Many of the students, which accounted for 85.7% of the total, indicated that they strongly agreed with the statement by selecting the response option "Strongly agree." Based on this sizeable percentage, it appears that the students have a favorable disposition toward making regular use of the augmented reality system, which indicates that they have a positive reaction to the application. Furthermore, it is worth noting that 10.7% of students chose the "Agree" option, which further bolsters the good mood for regular use. The general positive response of the augmented reality e-learning application among the student cohort is further highlighted by the fact that the combined percentage of those who either "Strongly agree" or "Agree" represents a solid majority.

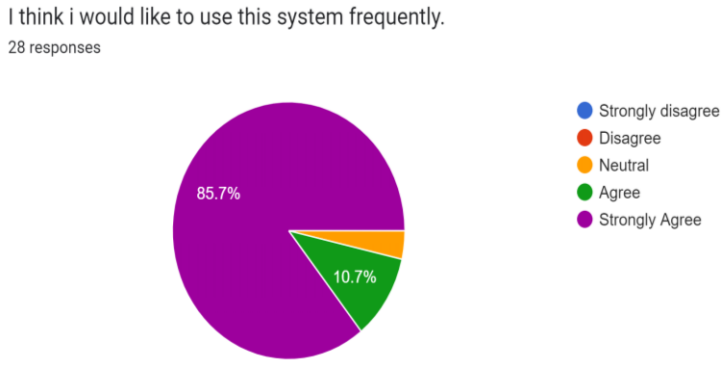

Figure 4 Pie Chart Representing Question 1 of System Usability Scale

In figure 5 to question number two of the System Usability Scale, which evaluates the perceived complexity of the system by using the statement "I found the system unnecessarily complex," the responses from the students revealed significant patterns. There was a widespread opinion among the majority of participants, as evidenced by the fact that 87.5% of the students indicated that they strongly disagreed with the idea that the system was unnecessarily complicated. In addition, a sizeable number of 10.7 percent took a neutral approach, which reflects a degree of ambivalence or hesitation regarding the perceived complexity of the situation. The remaining percentage of students dispersed their comments throughout the many different options that were presented to them, so providing a nuanced spectrum of perspectives regarding the complexity of the system. This disparity in replies draws attention to the various characters of user perceptions and emphasizes the significance of taking into consideration a variety of views while evaluating the augmented reality e-learning application.

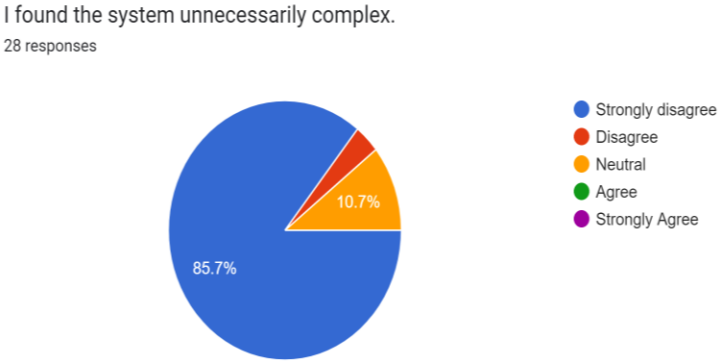

Figure 5 Pie Chart Representing Question 2 of System Usability Scale

In response to question number three in figure 6 on the System Usability Scale, which evaluates participants' impressions of the system's ease of use by using the phrase "I thought the system was easy to use," the majority of students indicated that they were in agreement with the statement. To be more specific, 85.7% of the students chose the response choice that was called "Strongly agree." The remaining % of pupils dispersed their responses throughout the several alternative options that were provided to them respectively. Regarding the perceived ease of use of the system, this data indicates that the participants had a strong positive inclination, which reflects a favorable user experience in terms of the system's navigability and overall usability. As a result of the considerable percentage of students who strongly agree with the statement, the effectiveness of the augmented reality e-learning application is highlighted, and the user-friendliness of its design is confirmed from the point of view of the individuals who participated in the survey.

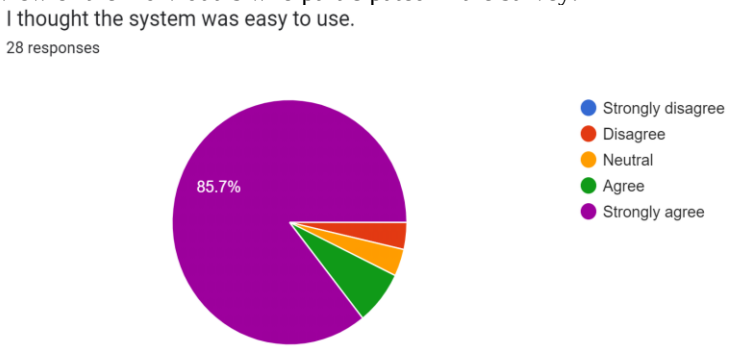

Figure 6 Pie Chart Representing Question 3 of System Usability Scale

Regarding question #4 in figure 7 of the System Usability Scale, which evaluates the extent to which technical support is perceived as necessary for system usage, a significant 89.3 percent of the student respondents conveyed a strong disagreement with the assertion. Students' self-perceived competence and confidence in navigating and utilizing the augmented reality e-learning application designed for the ninth-grade physics chapter on Work and Energy are significantly elevated. The proportions that remained were allocated to alternative response choices, indicating that students had little propensity to seek external technical support; this finding further underscores the application's user-friendly attributes, as perceived by the majority of the respondents. The achieved result serves as evidence of the effective conception and execution of the augmented reality (AR) application, cultivating in students a feeling of independence and self-reliance when it comes to engaging with educational technology.

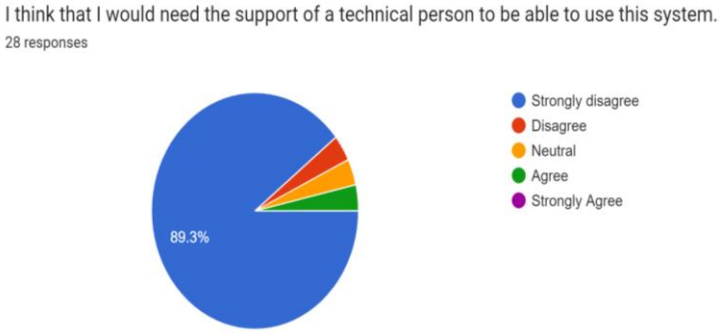

Figure 7 Pie Chart Representing Question 4 of System Usability Scale

The student feedback regarding System Usability Scale query #5, as depicted in figure 8, which evaluates the perceived integration of different functions within the system, indicated that positive endorsement predominated. The response of "Strongly Agree" was endorsed by a substantial majority of 85.7 percent of the

participants, indicating a solid consensus regarding the smooth integration of functionalities within the system under evaluation. In addition, ten percent of students concurred with the statement, which is consistent with the general favorable perception of the integrated functionalities of the system. The remaining responses were allocated among alternative choices, thereby showcasing the diverse array of perspectives present among the student body. The presented data not only highlights the positive assessment of the majority regarding the functional cohesion of the system, but also offers a nuanced comprehension of the varied viewpoints held by participants concerning the integration of different system functions.

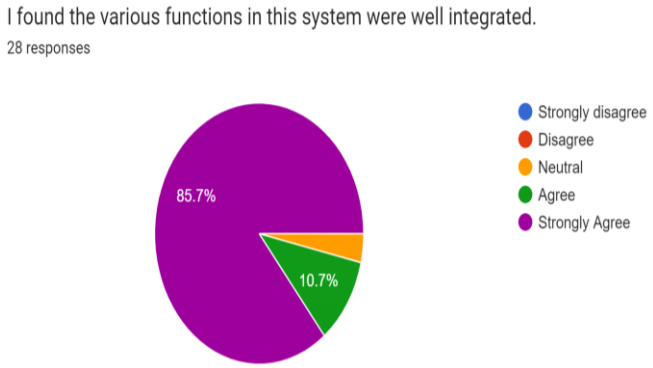

Figure 8 Pie Chart Representing Question 5 of System Usability Scale

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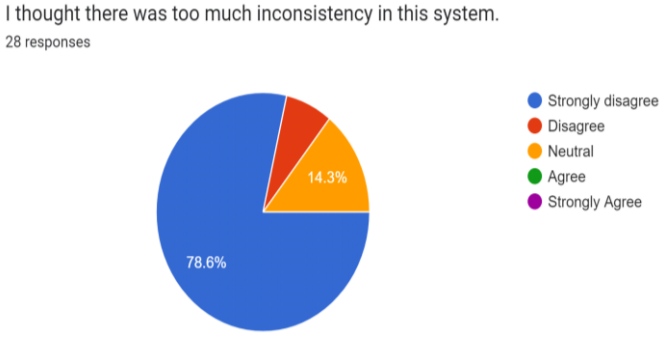

Figure 9 Pie Chart Representing Question 6 of System Usability Scale

The student respondents to question #6 on the System Usability Scale, which asked, "I perceived an excessive amount of inconsistency in this system," provided a range of response options (see Figure 9). Significantly, a considerable majority of the respondents (78.6%) expressed strong disagreement with the statement, suggesting that they held a positive perception of the consistency of the system. A minority, yet significant proportion, comprising 14.3 percent, maintained a neutral stance in their evaluation. The opinions of the remaining respondents, who were dispersed among the remaining response categories, were diverse with respect to the system's perceived consistency. The provision of this intricate feedback regarding the degree of consistency grants significant insights into the user experience, facilitating a more holistic comprehension of the system's merits and possible avenues for enhancement.

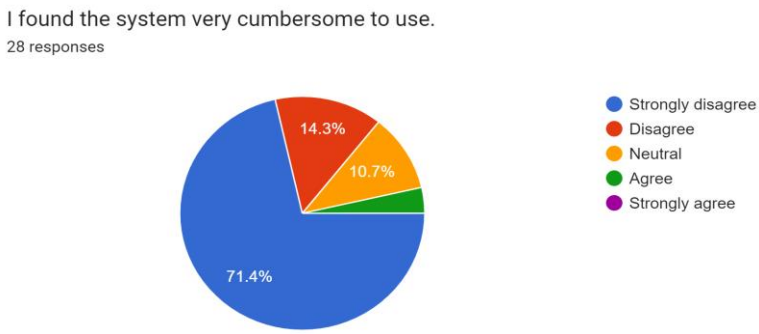

Figure 10 Pie Chart Representing Question 7 of System Usability Scale

The students provided detailed responses to question #7 on the System Usability Scale (Figure 10), which assesses the perception of the system's usability in relation to its burdensome nature. Significantly, 71.4% of the respondents expressed significant disagreement with the statement, suggesting that the augmented reality e-learning application is generally perceived as simple and effective to use. An additional 14.3% of respondents indicated dissent, indicating the presence of a minority viewpoint that perceived the system as moderately onerous. Additionally, a neutral position was adopted by 10.7% of respondents, who neither significantly agreed nor disagreed with the statement that the system was complicated. The inclusion of a portion of the respondents who selected alternative response options introduces an additional level of variability, thereby emphasizing the wide range of viewpoints present among the participants. The responses to question #7 on the System Usability Scale provide significant contributions to the overall comprehension of the application's usability by revealing how the students perceived its simplicity of use.

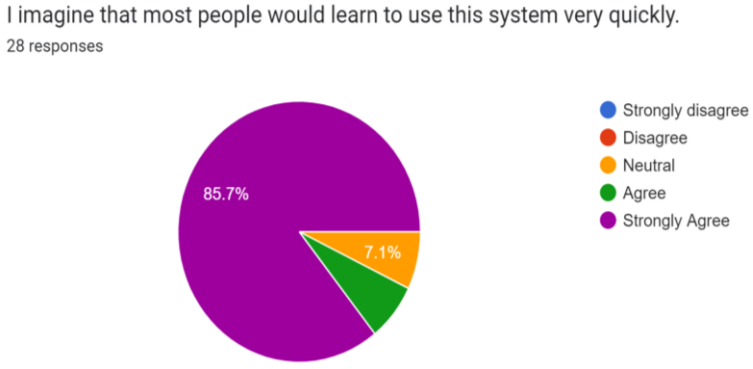

Figure 11 Pie Chart Representing Question 8 of System Usability Scale

Regarding question #8 of the System Usability Scale, which states, "It is reasonable to assume that the majority of individuals could rapidly master this system," the students who took part in the research demonstrated a significant pattern in their responses. A significant majority of the respondents (85.7 percent) strongly agreed with the statement, suggesting that the AR e-learning system was generally regarded as user-friendly and straightforward to master. On the contrary, a mere 7.1 percent of respondents maintained a neutral position regarding the system's swift learnability. The remainder of the percentage was allocated

to alternative response choices, indicating a diverse range of perspectives regarding the simplicity of mastering the application. The statistical analysis presented herein offers a comprehensive comprehension of the participants' perspectives concerning the learning curve linked to the augmented reality educational aid. This furnishes significant insights into the system's overall usability and accessibility.

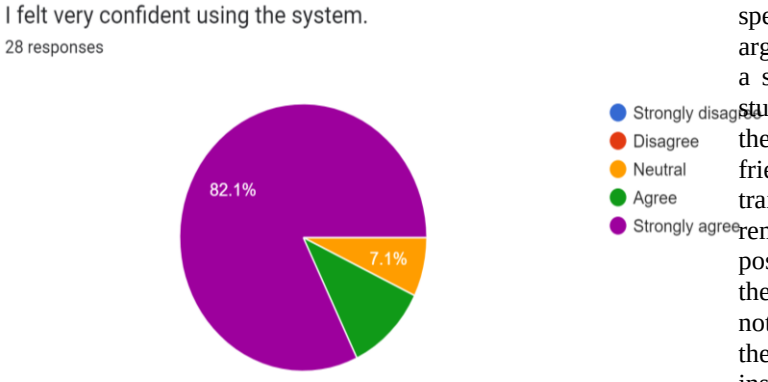

Figure 12 Pie Chart Representing Question 9 of System Usability Scale

In figure 12 the assessment of the efficacy of the augmented reality e-learning application utilizing the System efficacy Scale (SUS), particular emphasis was placed on inquiry number nine, which probed the level of confidence exhibited by the students in utilizing the system. The findings indicated a noteworthy pattern in the responses provided by the students, as a substantial majority conveyed a considerable degree of assurance. A significant majority of the respondents (82.1 percent) expressed firm agreement that they operated the system with utmost confidence. A minority of respondents (7.1 percent) expressed a neutral position regarding the confidence component. The remaining responses were allocated among the diverse array of alternatives presented, thereby capturing a spectrum of emotions concerning the students' perceived levels of assurance when engaging with the augmented reality e-learning application. The in-depth examination of question #9 provides significant contributions to the knowledge base regarding the users' confidence and ease in using and navigating the educational technology. As a result, a more comprehensive comprehension of the application's overall usability from a user-centric standpoint is achieved.

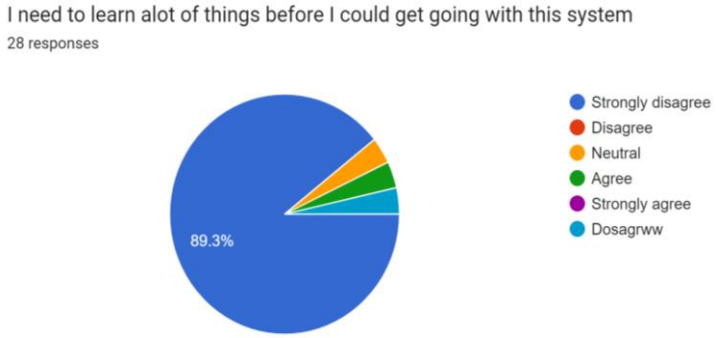

Figure 13 Pie Chart Representing Question 10 of System Usability Scale

The tenth question of the System Usability Scale (SUS) questionnaire, which examines users' impressions regarding the ease of initiation and the learning curve associated with the system, provided responses that were remarkable. These responses are shown in figure 13. When specifically asked about the statement "I needed to learn a lot of things before I could get going with this system," a significant number of students, specifically 89.3 percent, voiced a strong disagreement with this argument. The overwhelming majority of students who indicated a strong disagreement suggests that a significant proportion of students found the augmented reality e-learning application for the ninth-grade physics chapter on Work and Energy to be user-friendly and intuitive. It required minimal pre-learning or training before effective engagement could take place. The remaining % was spread among the many alternative response possibilities, which consequently reflected an agreement among the participants that the program was easily accessible and did not need a steep learning curve, which contributed positively to the application's overall usefulness. Not only does this particular insight into user perceptions regarding the learning needs for system commencement provide useful feedback for enhancing the application's onboarding process, but it also highlights the potential efficacy of the augmented reality educational tool in reducing the barriers to entrance for students.

IV. Conclusion

The results obtained from the assessment of the augmented reality (AR) e-learning application designed for the ninth-grade physics chapter on Work and Energy, employing the System Usability Scale (SUS), provide an all-encompassing comprehension of the perceptions and experiences of the students. Every SUS question explored a unique aspect of usability, and the resulting analyses offer significant insights into the AR application's strengths and areas that require development. As shown in Figure 4, the responses of students regarding the frequency of application usage indicated a unanimous agreement, as 85.7% of them firmly agreed that they utilized the AR system on a regular basis. The overwhelming majority expresses a favorable inclination towards maintaining consistent usage of the application, thereby validating a positive response to the learning instrument. Furthermore, the substantial majority of respondents who either firmly agreed or agreed with the augmented reality e-learning application's claims underscored the application's generally favorable reception. The findings presented in Figure 5, which examines the perceived complexity of the system, indicate that 87.5% of students strongly disagreed that the system was overly complicated. Although 10.7% of the respondents maintained a neutral position, the range of opinions emphasized the significance of taking into account various viewpoints when evaluating the complexity of the application. Regarding students' perceptions of the system's usability, Question 3 (Figure 6) revealed that 85.7% of respondents firmly agreed that the system was intuitive. The considerable proportion signifies a pronounced inclination in the positive, thereby validating the application's intuitive interface and straightforward navigation. In regard to the indispensability of technical support, Figure 7 demonstrates that a substantial 89.3% of respondents firmly disagreed with the claim, reflecting the students' perception of their own ability and confidence in independently

operating the augmented reality application. This discovery highlights the intuitive qualities of the application and the development of a sense of independence it fosters in students. In relation to the integration of various functions (Figure 8), a significant majority of 85.7% expressed strong agreement that the functionalities of the system were effectively integrated. The diverse range of responses underscores the positive evaluation as well as the intricate nature of the perspectives concerning functional cohesion in the system. Regarding students' perceptions of system consistency, as shown in Figure 9, 78.6% were adamantly opposed to the notion of perceived inconsistency. The prevailing opinion indicates that the system's consistency is well-received, providing significant insights into the overall user experience. In response to Question 7 (Figure 10), which examined the burdensome nature of the system in terms of usability, 71.4% of respondents strongly disagreed, suggesting that the AR application is generally perceived as being user-friendly and efficient. This, in conjunction with supplementary viewpoints, provides a comprehensive comprehension of the efficacy of the application. In response to Question 8 (Figure 11) regarding the system's rapid mastery, 85.7% of respondents strongly agreed, highlighting the widespread perception that the augmented reality e-learning system is intuitive and simple to master. Students' confidence in system utilization was evaluated in Figure 12, with 82.1% indicating strong agreement. The considerable majority suggests that students have a reasonable amount of assurance when utilizing the augmented reality e-learning application. In the tenth inquiry (Figure 13), which examined the learning trajectory, a significant majority of 89.3% expressed strong disagreement with the proposition that the system should require extensive prior learning. This majority indicates that the augmented reality application was intuitive and user-friendly to students, thereby lowering entry barriers. In general, the comprehensive examination of SUS responses consistently underscores a favorable user experience, with particular emphasis on the augmented reality application's intuitive interface, efficient layout, and overall effectiveness in promoting learning. These observations can provide guidance for future improvements, guaranteeing sustained favorable user experiences in the domain of augmented reality-driven instruction for physics subjects such as Energy and Work in ninth-grade classrooms.

V. Future Work

To identify the way an augmented reality app can be utilized to incorporate adaptive learning strategies in order to individualize the learning experience for each student. By adjusting content delivery, scheduling, and assessments to correspond with the distinct learning styles and capabilities of individual students, adaptive learning algorithms have the potential to improve both student engagement and knowledge retention.

References

[1] Khan, T., Johnston, K., & Ophoff, J. (2019). The Impact of an Augmented Reality Application on Learning Motivation of Students. Advances in Human-Computer Interaction, 2019. https://doi.org/10.1155/2019/7208494

[2] Saidin, N. F., Halim, N. D. A., & Yahaya, N. (2015). A review of research on augmented reality in education: Advantages and applications. International Education Studies, 13, 1–8. https://doi.org/10.5539/ies.v8n13p1

[3] Tzima, S., Styliaras, G., & Bassounas, A. (2019). Augmented reality applications in education: Teachers point of view. Education Sciences, 9(2). https://doi.org/10.3390/educsci9020099

[4] H. Bint-E-Asim et al., "Exploring Interactive STEM in Online Education through Robotic Kits for Playful Learning," vol. 19. [Online]. Available: http://xisdxjxsu.asia

[5] M. Hadi et al., "Exploring Freelancing as a Novice: Effective Strategies and Insights for Achieving Success." [Online]. Available: http://xisdxjxsu.asia

[6] T. Lashari et al., "Impact of custom-built video game simulators on learning in Pakistan using Universal Design for Learning." [Online]. Available: http://xisdxjxsu.asia

[7] A. S. Samad Danish et al., "Implementation of Smart Aquarium System Supporting Remote Monitoring and Controlling of Functions using Internet of Things," Journal of Multidisciplinary Approaches in Science (JMAS), 2019.

[8] A. S. Danish et al., "Comparative Study of Conventional Methods and Augmented Reality: Effects on Class Performance," Journal of Multidisciplinary Approaches in Science, vol. 7. [Online]. Available: https://www.researchgate.net/publication/337561169

[9] M. Quwaider et al., "The Impact of Video Games on the Players Behaviors: A Survey," Procedia Computer Science, vol. 151, pp. 575-582, 2019.

[10] G. Cui et al., "The Dampening Effects of Perceived Teacher Enthusiasm on Class-Related Boredom: The Mediating Role of Perceived Autonomy Support and Task Value," 2017.

[11] S. Mann, A. Robinson, "Boredom in the lecture theatre: An investigation into the contributors, moderators and outcomes of boredom amongst university students," vol. 35, no. 2, pp. 243-258, April 2009.

[12] M. Trow, "Problems in the Transition from Elite to Mass Higher Education," J. Name Stand. Abbrev., in press.

[13] J. M. Breiner et al., "What Is STEM? A Discussion About Conceptions of STEM in Education and Partnerships," 2012.

[14] R. Bailey et al., "The educational benefits claimed for physical education and school sport: an academic review," Research Papers in Education.

[15] Ahmed, D., Dillshad, V., Danish, A. S., Jahangir, F., Kashif, H., & Shahbaz, T. (n.d.). *Enhancing Home Automation through Brain-Computer Interface Technology*. http://xisdxjxsu.asia

[16] Danish, A. S., Khan, Z., Jahangir, F., Malik, A., Tariq, W., Muhammad, A., & Khan, Y. (n.d.). Exploring the Effectiveness of Augmented Reality based E-Learning Application on Learning Outcomes in Pakistan: A Study Utilizing VARK Analysis and Hybrid Pedagogy. http://xisdxjxsu.asia

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