Evaluating the Efficacy of Augmented Reality Technology for COVID-19 Education and Knowledge Enhancement

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Abstract

The global COVID-19 pandemic has precipitated an unprecedented crisis, necessitating widespread travel restrictions and stringent social distancing measures. This health emergency has presented multifaceted challenges to contemporary society, highlighting the imperative for innovative educational solutions to disseminate crucial information about the virus and its ramifications. Augmented Reality (AR) technology emerges as a promising digital tool uniquely positioned to address these challenges, offering immersive and interactive learning experiences. In a recent study evaluating the efficacy of AR technology in COVID-19 education, researchers developed a bespoke augmented reality mobile application designed to impart knowledge about the virus. The study's primary objective was to gauge the impact of this educational tool on participants' learning outcomes through pre-and post-tests. Thirty participants were enlisted to interact with the AR application, yielding findings that demonstrated a significant enhancement in knowledge and comprehension of COVID-19 after its utilization. These results underscore the potential of AR technology as a potent educational tool in disseminating essential information about COVID-19. The interactive nature of AR facilitates deeper engagement and understanding among learners, offering promising avenues for enhancing public awareness and preparedness in navigating health crises. Further research in this domain is warranted to fully harness the potential of AR technology in addressing global health challenges.

Keywords: COVID-19, Augmented Reality, Health Crisis, Learning Outcomes

Introduction

Augmented Reality (AR) technology is both intriguing and widely utilized. It enables the integration of virtual objects into the real environment, facilitating real-time interaction (Martín-Gutiérrez et al., 2015)(Jiang et al., 2022). By seamlessly overlaying digital data and content onto the physical world, AR creates the impression of intricately embedded information, as intended by the creator. This extends the perception of information and

content beyond what is directly observable, transcending traditional limitations. When applied to education, particularly as a primary medium of instruction, AR transforms the learning experience from mundane printed materials into an engaging platform. Learners encounter a distinctive educational paradigm, fostering the integration of external knowledge into the classroom and motivating active engagement with lessons as dynamic entities.

In the context of this research, a three-dimensional AR application was developed to enhance public understanding of COVID-19 preventive measures. The application leverages AR to transform learning about the virus into an engaging, interactive platform. By utilizing AR, the project aims to increase public engagement and make critical information about COVID-19 prevention more accessible and compelling. This approach is particularly relevant in the New Normal era, where the public needs reliable information to navigate health guidelines and adapt to new ways of living. The use of AR has become more accessible, eliminating the need for specialized equipment and enabling easy usage on mobile devices(Alzahrani, 2020)(Garzón, 2021)(Avila-Garzon et al., 2021)(Arena et al., 2022). Given the widespread ownership of mobile devices, access to AR has significantly expanded (Pelet, 2017)(Avila-Garzon et al., 2021).

The COVID-19 (Coronavirus Disease 2019) pandemic has significantly impacted public health and societal well-being (Shi et al., 2020). Additionally, there have been challenges in accessing public services due to the societal changes brought about by the New Normal era. Response measures to mitigate the impacts of COVID-19 include detailed guidelines for proper practices, relying on accurate and trustworthy information dissemination. These measures aim to reduce public health burdens on service providers, especially medical personnel, who face increased workloads amid manpower shortages. Meanwhile, service recipients have been affected by the implementation of new service formats and procedures, following policies to prevent the spread of COVID-19. Every sector is striving to adapt to this crisis. The adoption of a New Normal lifestyle emphasizes health maintenance, social distancing, and the embrace of new ways of living, often leveraging technology. However, a segment of the population still lacks knowledge and understanding regarding preventive measures against the coronavirus.

This research project recognized the potential of using three-dimensional Augmented Reality (AR) technology to disseminate knowledge about COVID-19. By utilizing AR technology, the aim was to enhance engagement and facilitate the transmission of information regarding preventive measures against COVID-19, thereby making the acquisition of knowledge more intriguing and accessible to a wider audience.

Literature Review

COVID-19

In December 2019, there was a report of an outbreak of an unidentified cause of pneumonia in Wuhan City, Hubei Province, China. This pneumonia was later associated with the Huanan Seafood Wholesale Market and was named as a severe, acute respiratory syndrome-related coronavirus 2 (SARS-CoV-2), a beta coronavirus under the subgenus Sarbecovirus. The global spread of SARS-CoV-2 led the World Health Organization to declare a pandemic on March 12, 2020. The world has experienced significant repercussions from this pandemic, including human casualties, economic impacts, and increased adversity (Ciotti et al., 2020). The sudden severe acute respiratory syndrome caused by the SARS-CoV-2 virus strain 7 in humans was discovered in Wuhan City, Hubei Province, China, during the recent outbreak of pneumonia in January 2020 (Zhou et al., 2020)(Wu et al., 2020). The current

COVID-19 outbreak is considered a global emergency due to its rapid spread and high mortality rates (Yang et al., 2020). The number of individuals infected with the SARS-CoV-2 virus, the cause of severe acute respiratory syndrome (SARS-CoV-2), is increasing rapidly worldwide. COVID-19 patients may suffer from pneumonia (Zhu et al., 2020)(Huang et al., 2020), severe acute respiratory distress syndrome (ARDS), and multiple organ failure (Chen et al., 2020)(Wang et al., 2020). Generally, human coronaviruses OC43, NL63, HKU1, and 229E cause mild self-limiting diseases (Corman et al., 2018).

Augmented Reality

Augmented Reality (AR) is an environment created to simulate the real environment by utilizing digital image display components, including sound and other stimuli, through holographic technology. AR seamlessly combines the real and virtual worlds by enriching the real world with computer-generated virtual objects in real-time (Alzahrani, 2020)(Maulana, 2020)(Fan et al., 2020)(Iatsyshyn et al., 2020)(Avila-Garzon et al., 2021). According to the widely accepted definition, AR is considered a technology governed by three fundamental principles: the integration of real and virtual objects in a real environment, the alignment of real and virtual objects, and real-time interaction (Martín-Gutiérrez et al., 2015)(Arici et al., 2021)(Anuar et al., 2021)(Jiang et al., 2022)(Mendoza-Ramírez et al., 2023).

While computers connected to the internet allow us to be part of an interconnected world, the reality is that connectivity has expanded to other devices like smartphones, tablets, watches, and even glasses. This expansion allows us to receive information more naturally, in a way that's easy and swift. Indeed, we've broadened our view of reality by utilizing computers. Thanks to smartphones, the usage of Augmented Reality has increased, extending its scope to entertainment, marketing, tourism, education, and healthcare. The term 'Augmented Reality' also refers to a complex set of technologies that enable us to create three-dimensional images, construct new virtual worlds, and manage virtual objects. This is known as immersive virtual reality. When considering the increasing complexity of the technology used in Augmented Reality, it's categorized into different levels; Level 0: Physical World Hyper Linking involves using codes such as QR codes to link to related content like hyperlinks, images, text, sound, or standard videos. Level 1: Marker-Based AR uses geometric shapes like black and white square markers, often a simple and asymmetrical square shape, allowing the overlay of three-dimensional objects and recognition. Level 2: Markerless Augmented Reality enables overlaying data in physical world scenes triggered by images, objects, or people without markers, sometimes utilizing GPS technology. Level 3: Immersive Virtual Reality or Augmented Vision, the most intrusive level, replaces computer screens and mobile devices with glasses, lenses, or special sensors, providing a fully immersive experience in a three-dimensional world. This technology's development has revolutionized our understanding of reality, introducing a new way to experience and interact with the world.

Research Methodology

Conceptual Framework

This work can be summarized as follows:

Step 1: Data Acquisition: Collection of COVID-19 Content

The process begins with the acquisition of content related to COVID-19. This involves gathering relevant information, data, and resources that will form the basis of the AR experience.

Step 2: Feature Identification: Unity-Based AR Development

After collecting the content, the next step is to identify and define the features that will be integrated into the AR application. The development of this AR experience is carried out using Unity, a popular game development platform, to create an interactive and educational tool with the collected COVID-19 content.

Step 3: Evaluation: Application Testing by Participants

The developed AR application is then subjected to an evaluation process. This stage involves applying the AR tool to a group of participants, which includes both specialists (n = 5) and students (n = 30), totaling 35 participants. The goal is to assess the effectiveness and usability of the AR application within these groups. This step involves a comprehensive evaluation of the AR application through several key activities:

- Satisfaction: Usability Feedback from Participants

Following the evaluation, feedback is gathered from the participants regarding their satisfaction and the usability of the AR tool. This feedback is crucial in understanding the user experience and identifying areas for improvement. All 35 participants provide this feedback.

- Pre-Test and Post-Test

To measure the educational impact of the AR application, a pre-test and post-test are conducted. These tests are designed to evaluate the knowledge gain of the participants before and after using the AR application.

- Analysis of Relative Gain and Difference Scores

The final step involves analyzing the data collected from the pre-test and post-test. This analysis focuses on the relative gain and difference scores, which help to quantify the effectiveness of the AR application in improving the participants' understanding of COVID-19 content.

The process outlined in Figure 1 provides a concise summary of the work (Luangrungruang & Kokaew, 2022).

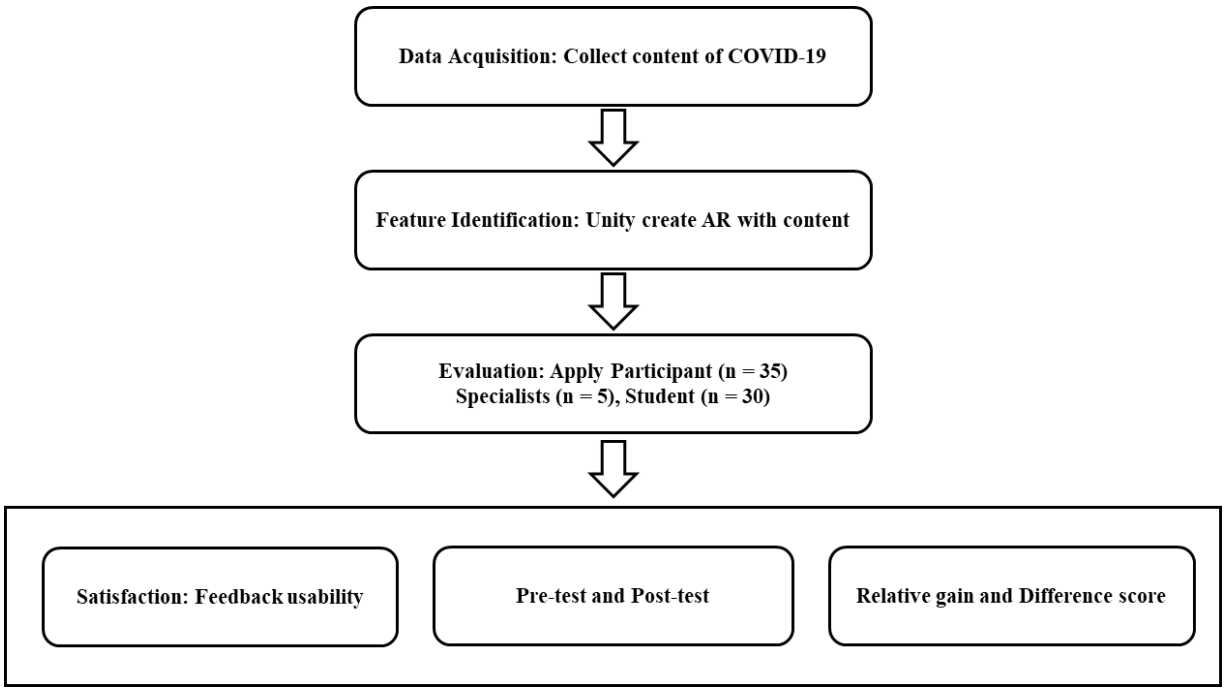

Figure 1: Flowchart of work

Figure 2 depicts the user interaction with the application using AR technology related to COVID-19. Upon launching the application, users access the main menu. Upon selecting the AR menu, the camera activates to search for and detect markers (marker images). Successful marker detection triggers the display of virtual objects. Users can navigate back to the main menu of the application while engaging in various activities. Exiting the application results in the complete cessation of all functionalities within the application.

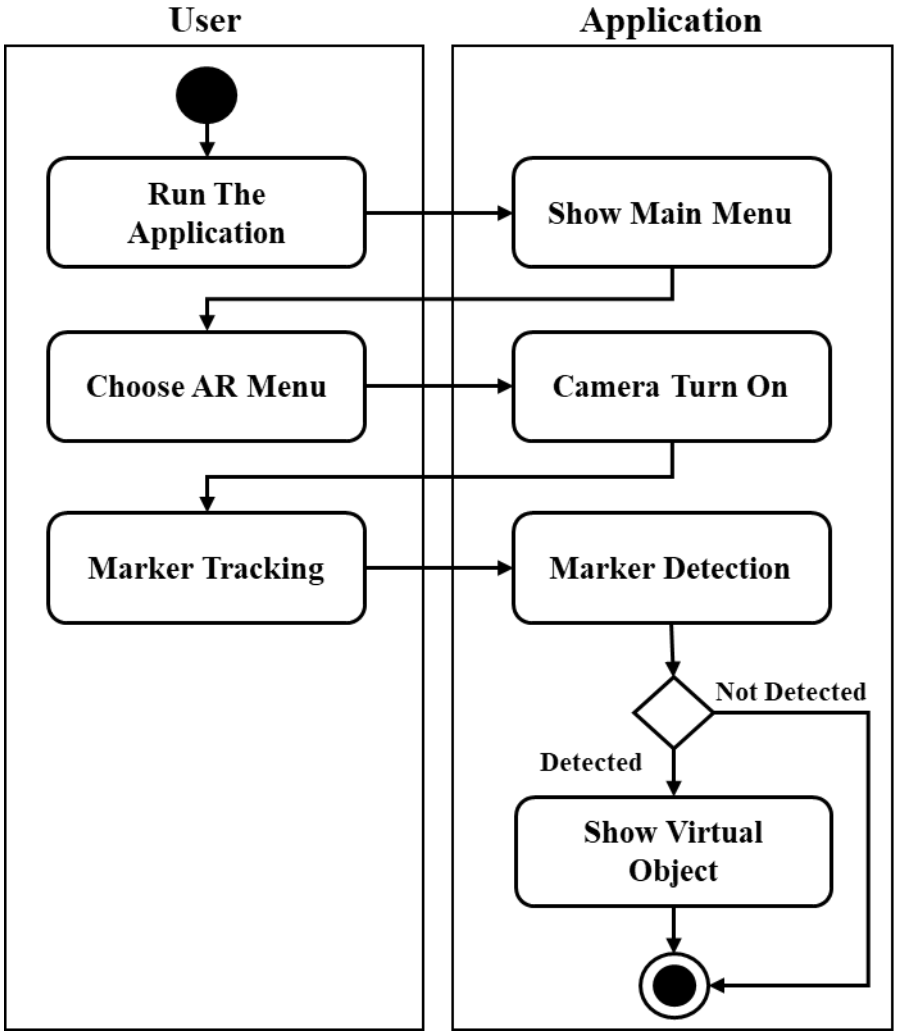

Figure 2: Application workflow diagram

The development outcomes of the COVID-19 educational application using AR technology consist of three components: the COVID-19 educational application, an evaluation of effectiveness by experts, and an analysis of user satisfaction. The application includes a set of 10 markers and encompasses both pretest and posttest assessments. The design of the Main Menu display serves as the foundation for introducing the application. It showcases the application's name and menu options, allowing users to navigate through various features. The Main Menu comprises six buttons: Scan AR, Guide, Pre-Test, Post-Test, About, and Exit application. Selecting the 'Scan AR' option opens the smartphone camera. Point the camera at

the marker to reveal the related 3D image. Detailed information about the model can then be accessed, as depicted in Figure 3.

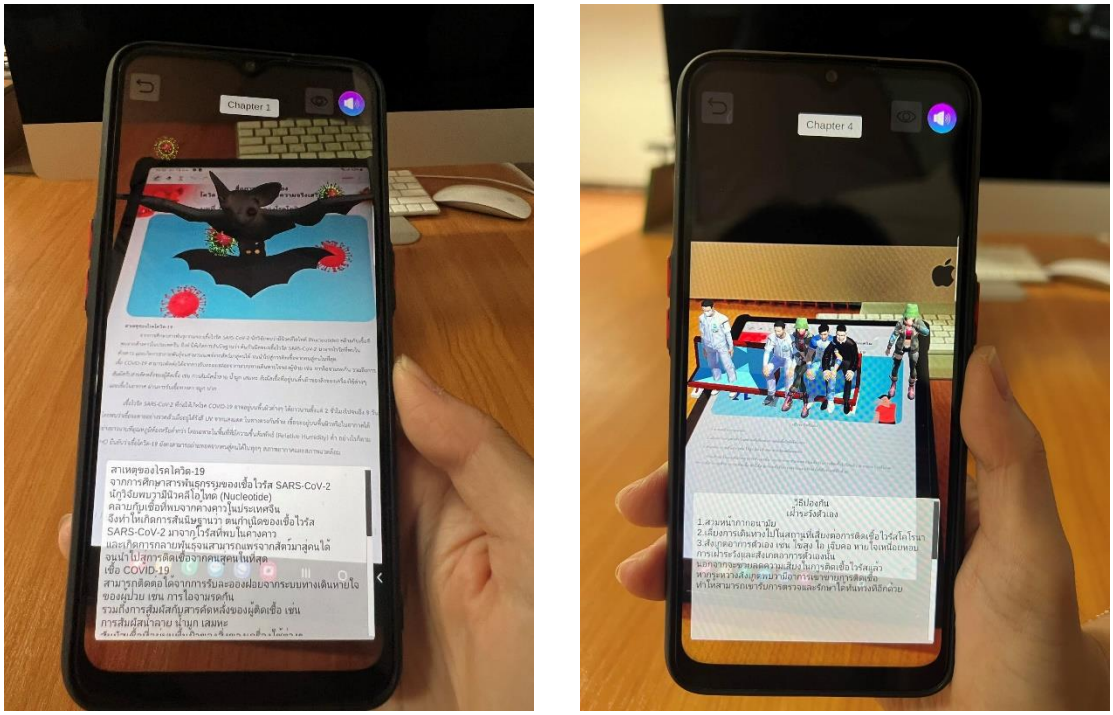

Figure 3: Example of providing AR information (animation and simulation)

Research Finding

The research findings indicate that using Augmented Reality (AR) technology to disseminate and communicate information can be highly effective. By integrating AR into educational tools, an interactive learning experience can be created, enhancing the understanding of presented information. This approach aims to make the dissemination of knowledge more engaging and accessible, providing users with a dynamic and visually appealing method for receiving and absorbing content.

Assessment by 5 specialists, individuals employed at Sakon Nakhon Rajabhat University, knowledgeable about augmented reality-based learning media, revealed that the aspect receiving the highest evaluation was the usability of the application, with an average score of 4.80, indicating a significantly high rating. The overall average score for all aspects of the COVID-19 educational application utilizing augmented reality technology on the Android operating system was 4.75, indicating a considerably high level shown as Table 1.

Table 1: Results of satisfaction assessment regarding the usage of the application

Evaluation	Average	S.D.	Interpretation of results
1. Content	4.72	0.35	Very Good
2. Design	4.72	0.39	Very Good
3. Usage aspect of the application	4.80	0.30	Very Good
Summary	4.75	0.22	Very Good

The statistical analysis of the data involves using mean and standard deviation. Testing the application's usability aligns with the objectives and employs questionnaires as a tool to measure user satisfaction. Result of Satisfaction Assessment for the COVID-19 Educational Application using Augmented Reality assessment by 30 students shown as Table 2.

Table 2: Results of satisfaction assessment regarding the usage of the application

Evaluation	Average	S.D.	Interpretation of results
1. Content	4.04	0.62	Good
2. Design	4.17	0.73	Good
3. Usage aspect of the application	4.29	0.67	Good
Summary	4.17	0.10	Good

From Table 2, the summary of satisfaction assessment results ranked each aspect in descending order based on the average scores given by 30 students from Sakon Nakhon Rajabhat University regarding the COVID-19 educational application using augmented reality technology on the Android operating system. The overall average satisfaction score was 4.17, indicating a good level.

The results indicated that the assessment of learning effectiveness was conducted by establishing learning hypotheses, calculating difference scores, and determining relative gains. The average post-learning score exceeded 50% of the total possible score, demonstrating a significant improvement in learning outcomes facilitated by the educational media.

Pre-tests and post-tests are essential tools for assessing learning effectiveness. The pre-test establishes the participants' baseline knowledge before the educational intervention, while the post-test measures the learning outcomes after the intervention. By comparing these results, educators can evaluate the effectiveness of the intervention and identify areas for further improvement. The results of the pre-test and post-test are presented in Table 3 as follows.

Table 3: Results of pre-test and post-test in learning outcomes

Student No.	Pre-Test	Post-Test	Student No.	Pre-Test	Post-Test
1	5	17	**16**	8	17
2	10	20	**17**	7	18
3	8	14	**18**	6	15
4	9	16	**19**	9	15
5	4	12	**20**	8	14
6	6	9	**21**	8	16
7	5	14	**22**	5	12
8	5	14	**23**	7	15
9	7	12	**24**	8	12
10	12	16	**25**	3	16
11	8	16	**26**	7	12
12	9	20	**27**	7	16
13	14	15	**28**	9	10
14	7	20	**29**	8	16
15	14	17	**30**	7	16

Figure 4 illustrates the difference scores, indicating the improvement in learning outcomes between the pre-test and post-test.

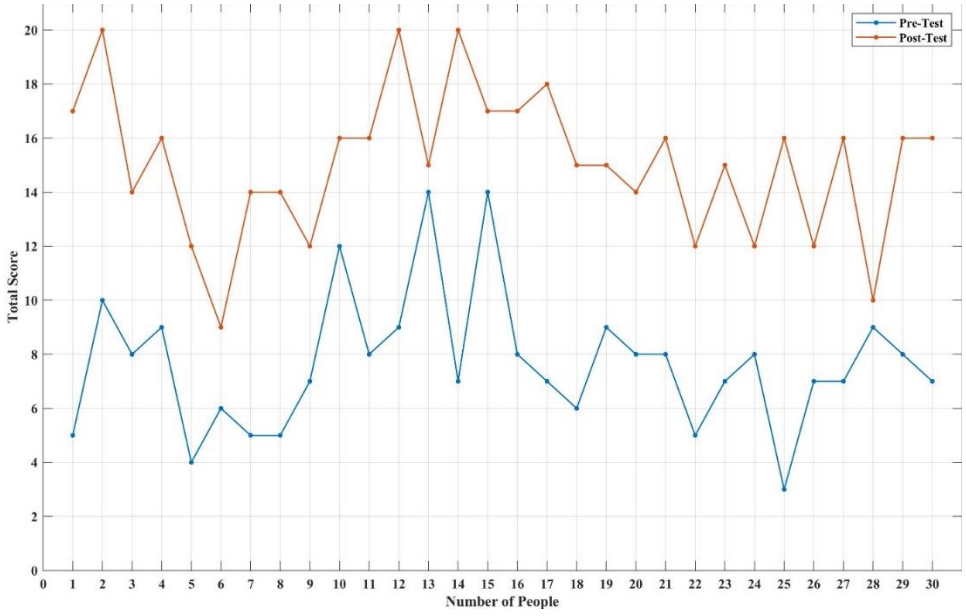

Figure 4: Comparative analysis between pre-test and post-test

Meanwhile, Figure 5 portrays the relative gain scores, providing an overview of the learning development (Kanjanawasee, 1990). The study exhibits enhanced learning outcomes that indicates that all 30 students demonstrated improved performance.

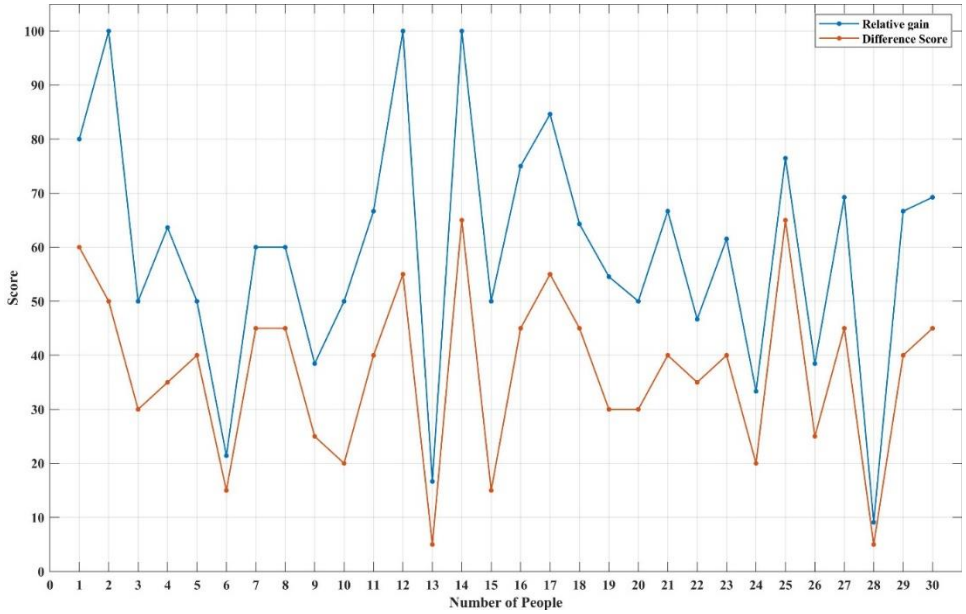

Figure 5: Comparative analysis between relative gain and difference score

Regarding the pre-test and post-test learning outcomes from a 20-question test, after the learning session using the COVID-19 educational application, it was observed that 29 students passed the criterion while one student did not. The average score after learning was 15.07, which is 75.33% of the total score, compared to the pre-test average score of 7.67, equivalent to 38.33% of the total score. When comparing the post-test scores against the 50% criterion, it was found that 29 students exceeded this benchmark, accounting for 96.67%. This outcome indicates that the COVID-19 educational application, as evaluated through the test, effectively enhanced the students' understanding and knowledge of COVID-19, aligning with the initial research hypothesis.

Discussion/Conclusion

Summarizing the results obtained from developing augmented reality (AR) learning aids for COVID-19, along with recommendations, the objective was to engage learners in wanting to explore COVID-19 and coronavirus-related information. Researchers proposed an educational tool using AR technology on Android devices to accurately and conveniently facilitate learning. This technology was utilized for its beneficial and creative nature.

To evaluate the efficacy, researchers developed and tested the program. Upon confirming the model's alignment with content, use of understandable language, and accuracy, the educational material underwent additional testing. Subsequently, experts assessed its effectiveness across three aspects: 1) media creation, 2) technology, and 3) application. The evaluation resulted in highly satisfactory ratings, averaging 4.75. Moreover, after using the AR-enhanced learning material, the experimental sample group reported a high satisfaction

level, averaging 4.17. From these results it can be stated that the AR application can be used easily by users so that it is expected to support future activities.

The learning outcomes of students at Sakon Nakhon Rajabhat University concerning COVID-19, utilizing augmented reality technology, significantly improved their knowledge and understanding. Pre-test scores averaged 7.67, while post-test scores averaged 15.07, reflecting an average difference of 7.40 points. The standard deviation for pre-test scores was 2.52 and 2.72 for post-test scores. The difference between post-test and pre-test scores averaged 3.19, indicating a significant improvement in learning outcomes. The relative scores of all students show an increase in their learning progress. These results align with the initial research hypothesis.

Suggestion

1. Extend the AR learning aids to cover a broader range of health-related topics beyond COVID-19, such as general virology, immunology, and public health measures.

2. Incorporate interactive elements such as quizzes, interactive 3D models, and virtual simulations to make learning more engaging.

3. Ensure the AR application is accessible to users with disabilities and is compatible with a wide range of devices, including those with lower specifications.

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