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Augmented Reality–Based English Learning Media Using a Target Tracking Model Approach

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Abstract: English language learners often experience difficulties in vocabulary acquisition due to inconsistencies between spelling and pronunciation, while conventional teaching methods may reduce student engagement. This study presents the development of an augmented reality (AR)–based English learning medium that employs a markerless target-tracking model to enhance vocabulary learning and the learning experience among elementary school students. The application was developed using the waterfall model and evaluated through a quantitative pre-experimental one-group pretest–posttest design involving 30 third-grade students across five testing sessions. Learning effectiveness was measured using pretest–posttest scores, while system quality and user perception were assessed using the System Usability Scale (SUS) and the User Experience Questionnaire (UEQ). The results demonstrate consistent improvements in students' learning outcomes across all sessions, indicating a positive impact of the AR-based learning media on vocabulary mastery. Usability evaluation produced a SUS score of 91, corresponding to Grade A ("Excellent"), while UEQ results showed positive impressions across all dimensions, including attractiveness, efficiency, and novelty. These findings indicate that the proposed AR learning media is highly usable, engaging, and effective in supporting English vocabulary learning. Overall, the study confirms that markerless AR learning media based on a target-tracking model have strong potential to enhance learning outcomes and experiences in elementary English education.

Keywords : Augmented Reality; Target Tracking Model; English Learning; System Usability Scale; User Experience.

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1. Introduction

English is an international language that is commonly used to communicate with people around the world; therefore, it is important for children to learn English from an early age [1]. In learning English, students often experience difficulties in reading and writing vocabulary because English spelling differs from its pronunciation (pronunciation). In addition, students frequently feel bored with learning activities that use monotonous methods [2]. Teachers typically only explain the material and then conclude the lesson by giving assignments. Therefore, enjoyable learning media are needed so that students have high learning motivation.

The learning media referred to in this study is an augmented reality–based application using a target tracking model approach. Augmented reality is a technology that can combine two- or three-dimensional virtual entities or objects with the real world in real time [3]. The target tracking model is one of the scanning methods in augmented reality that allows users to scan real objects directly without using markers or images.

Currently, several studies have discussed augmented reality in the field of learning, particularly foreign language learning [4], [5], and [6]. These three studies propose augmented reality–based learning applications using a marker-based tracking approach, which still relies on markers such as Quick Response (QR) codes and images. This method limits students in exploring their learning environment. In addition, a weakness of marker-based tracking is the need to prepare markers or images in advance as triggers to display 3D objects, and the pixel size of the image affects the scanning process [7].

Therefore, markerless tracking was chosen as the scanning method. Markerless tracking has several approaches; however, the chosen strategy must be adapted to specific needs. Markerless methods themselves face challenges in accurately displaying 3D objects. For example, in object tracking approaches, the sides and angles of each object must match those in the database [7]. Meanwhile, user-defined target and model-generated target approaches are more flexible, but when more than one data set is registered, they may sometimes display 3D objects that do not match the intended targets [8], [9]. Hence, further studies are needed on how to design learning strategies that can maximize learning experiences through the implementation of augmented reality–based learning media using a target tracking model approach.

To anticipate discrepancies between the scanned objects and the displayed 3D objects, scanning categories based on the type and object to be scanned are applied. The main features of the product include scanning real objects, displaying 3D objects that can be rotated, enlarged, or reduced, and providing accompanying audio and text. In addition, the application includes quizzes to assess students' understanding of the material presented in the application.

The target tracking model approach can be adapted into English language learning methods because it enables students to respond to spoken words (learning by doing), read and practice pronunciation (reading method), listen and play (songs and games method), and learn using familiar objects found in their surroundings (field study method) [10]. Research conducted by Sarkar [9] explains that object tracking without the use of markers (markerless tracking) can improve students' learning experiences, motivation, and learning outcomes. The results show that 90.4% of users favored augmented reality–based learning. The developed application employed a user-defined target approach, allowing users to search for and display 3D objects at predetermined locations. This approach encouraged users to discuss concepts with their peers and enhanced their immersive learning experience.

Arifitama [10] conducted a study comparing marker-based and markerless tracking methods for augmented reality objects. Image cards were used as scanning media for the marker-based approach, while flat surfaces were used for the markerless approach. The results indicated that markerless tracking performed better at a distance of 150 cm, achieving an accuracy rate of 93%, whereas marker-based tracking achieved only 83.3% accuracy with a precision rate of 50%.

Research by Astuti [7] discussed the development of an augmented reality–based application using a markerless object tracking approach. Object tracking was performed using real-world objects. The results showed that the accuracy percentage of tested objects based on viewing angle and distance reached ≥50%. The approach used was object tracking, in which every side and angle of the object was registered in the database. Consequently, each side and angle of the scanned object had to match the registered data in the database.

Arslan [11] conducted a study on the development of an augmented reality–based application for learning biological anatomy. The approach used was markerless user-defined target tracking. Data analysis results showed an average score of 85%, indicating good acceptance and positive responses from students. The application content displayed 3D anatomical objects of living organisms that could be enlarged, reduced, and moved. The scanning media used were flat surfaces or room walls.

Permana [12] discussed the design and development of visual learning media for digital object visualization using augmented reality technology with a model-generated target approach to display 3D coronavirus objects. The study concluded that the model-generated target approach increased students' participation and learning interest, while also assisting teachers in delivering learning materials more effectively and enjoyably. The scanning medium used was a spherical object whose model was registered in the database, generating a circular shape. As a result, any spherical object could be used as a scanning target to display the 3D coronavirus model.

Despite its advantages, markerless methods present challenges in accurately displaying 3D objects. In object tracking approaches, the sides and angles of each object must match those stored in the database. Meanwhile, user-defined target and model-generated target approaches are more flexible; however, when multiple datasets are registered, the system may sometimes display 3D objects that do not correspond to the intended targets.

Therefore, this study employs a target tracking model approach. To anticipate discrepancies between scanned objects and displayed 3D objects, scanning categories are applied based on the type and object being scanned. The main features of the developed product include scanning real objects, displaying interactive 3D objects that can be rotated, enlarged, or reduced, and providing accompanying audio and text. In addition, the application includes quizzes to assess students' understanding of the learning materials.

The target tracking model approach can be adapted to English language learning methods because it enables students to respond to spoken words (learning by doing), read and practice pronunciation (reading method), listen and play (songs and games method), and learn using familiar objects found in their surrounding environment (field study method) [8].

2. Method

The type of research used in this study is quantitative pre-experimental research [13], and the software development process employs the waterfall model [14]. The research methodology applied in this study is illustrated in Figure 1.

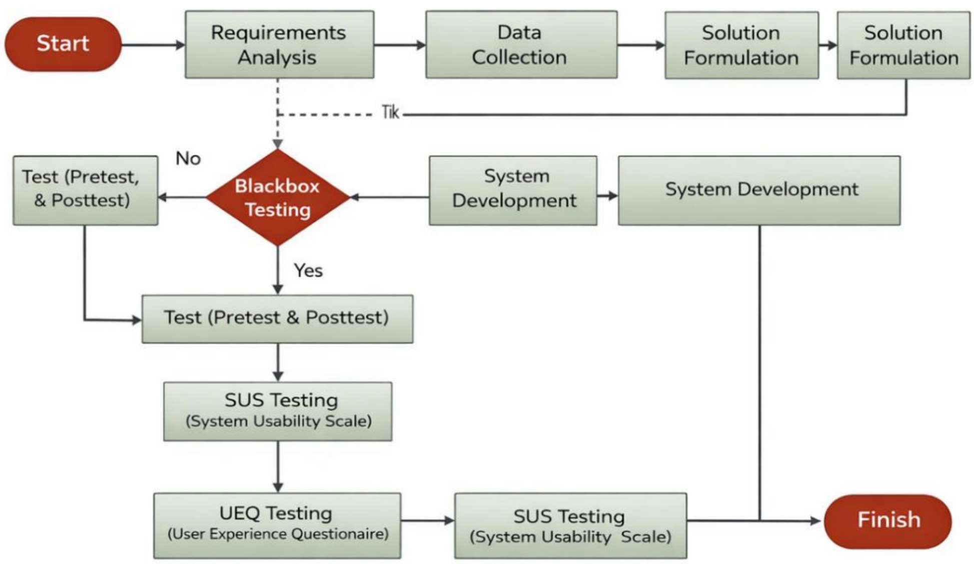

Figure 1. Research Methodology

2.1. Requirements Analysis

The target users of this application are third-grade students totaling 30 learners at Madrasah Ibtidaiyah Swasta (MIS) Karya Thayyibah (KT) LIMRAN. The application design must be user-friendly and easy to operate. The learning materials include vocabulary related to fruits, objects, and animals, accompanied by 3D objects, audio, and text. Additional content in the application includes quizzes containing questions related to the materials that have been studied within the application.

2.2. Data Collection

Data collection in this study involved two approaches: qualitative and quantitative. Qualitative data were collected through observations and interviews with teachers and students, while quantitative data were obtained from test results and questionnaires. These data were analyzed using the System Usability Scale (SUS) and the User Experience Questionnaire (UEQ).

2.3. Solution Formulation

Based on the previously identified problems, the proposed solution is the development of an augmented reality–based learning media application. The main features of this solution include a scanning process using the Target Tracking Model approach, which allows students to interact directly with real-world objects. The system is able to display 3D objects that can be rotated, enlarged, or reduced, and are accompanied by audio and text.

2.4. System Design

Application is designed according to user requirements using Unified Modeling Language (UML) diagrams. These include user requirements and system activity flows, as described below.

a. User Requirements Mapping

User requirements mapping illustrates the expected functionalities of the system and represents the interactions between actors and the system. The use case diagram illustrates an Augmented Reality (AR) learning system in which the student acts as the primary user interacting with various system features. Students begin by selecting a learning category, such as objects or animals, and then activate the AR experience through the play function, which leads to the AR camera page. On this page, students can view and interact with 3D AR objects using features such as rotation, zoom, language selection, and audio–text explanations to enhance understanding. The system utilizes camera detection to retrieve relevant AR content from a virtual database that stores models, learning materials, and supporting information. In addition to AR exploration, students can access quizzes to assess their understanding, with the system displaying questions and scores, as well as use help and information features for guidance and application details. The system also provides an exit function to safely close the application, ensuring a complete and user-centered learning experience. The user requirements are presented in Figure 2.

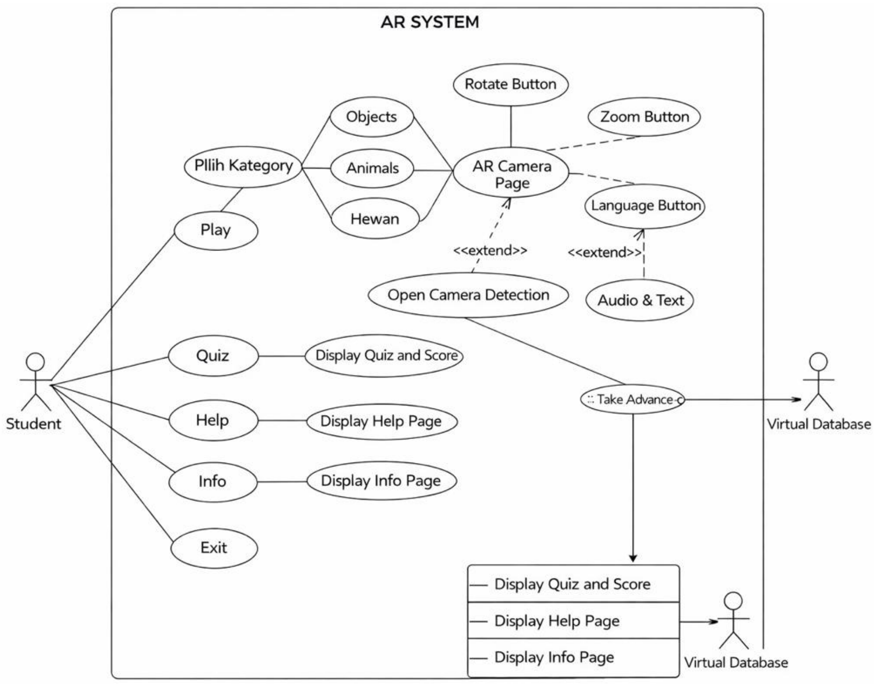

Figure 2. User Requirements

b. System Activity Flow

The system activity flow describes how the system process begins, the possible decisions that may occur, and how the system process ends. The diagram illustrates a swimlane-based interaction flow between the user, the system, and the database within an Augmented Reality (AR) learning application. The process begins when the user opens the application and selects the play option, followed by choosing a learning category and an AR object. The system then activates the AR camera page, performs object or marker detection, and displays the corresponding 3D AR model retrieved from the database. Users can interact with the AR object using rotation and zoom features, while the system processes these interactions in real time. Additionally, users may access audio and text explanations, which are fetched from the database and presented by the system to support learning. The interaction concludes when the user closes the application, marking the end of the system process and ensuring a structured and user-centered AR learning experience. The activity flow is illustrated in Figure 3.

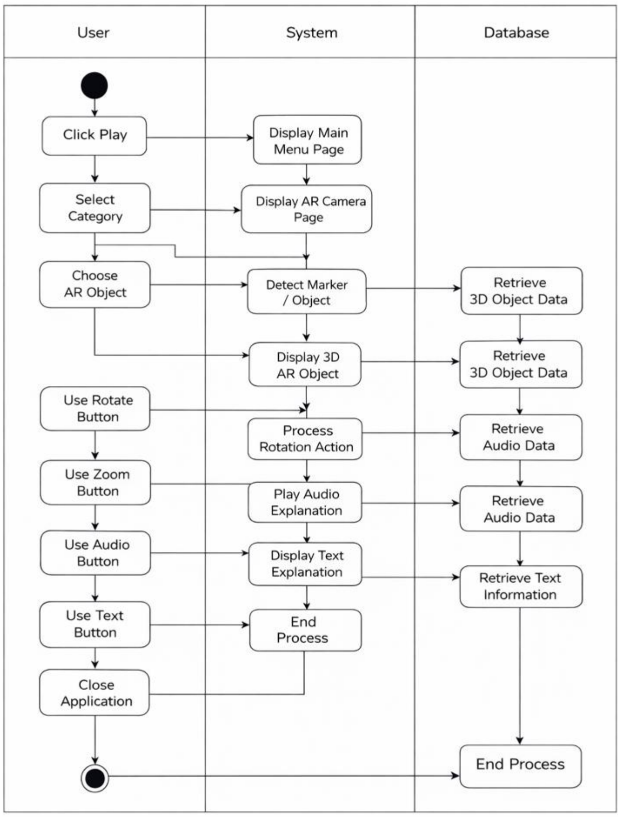

Figure 3. System Activity Flow

2.5 Implementation

Various assets and materials, including 2D images, object models, 3D objects, and audio. The second stage focused on designing the user interface by integrating the collected assets and materials using Unity 3D software. The user interface design is described as follows.

a. Main Menu Page

The main menu page consists of five navigation buttons that allow users to move to other pages. These buttons are Play, Quiz, Info, Help, and Exit. The main menu page is shown in Figure 4.

Figure 4. Main Menu Page

b. Category Selection Page
The category selection page appears after the user selects the Play button. This page provides three category options: fruits, objects, and animals. Each category contains six object options. The category selection page is shown in Figure 5, and object options for each category are presented in Figure 5.

Figure 5. Category Selection Page

(a) (b) (c)

Figure 6. Object Selection from the Selected Category

c. AR Camera Page
The AR Camera page consists of an AR camera view, a voice button to play audio along with text, a back button, a rotation button, and zoom in/out buttons. The AR camera page is shown in Figure 6.

(a) (b) (c)

Figure 6. AR Camera Page

d. Quiz Page

The quiz page contains multiple-choice questions, with each question worth 10 points. It consists of 10 questions related to the material learned in the AR Camera menu. Quiz page is shown in Figure 7.

Figure 7. Quiz Page

2.6. System Testing

After the application was completed, it was tested using four types of evaluations, as described below.

a. Black-Box Testing

Before the application was distributed, functional testing was conducted using the black box testing technique. Black-box is used to determine whether the program functions as expected or not [13].

b. Test (Pretest–Posttest)

The finalized application was then distributed to 30 third-grade students at Madrasah Ibtidaiyah Swasta Karya Thayyibah LIMRAN. The students were given multiple-choice tests conducted five times before and after using the application. This process was carried out to evaluate whether there were significant differences in students' learning outcomes before and after using the application [14], as well as to determine the effectiveness of the developed application on students' motivation and learning outcomes.

$$fx = \frac{\sum x}{N}$$

Where :

x = Average

$\sum x$ = Total score

N = Number of data points

c. System Usability Scale

System Usability Scale (SUS) testing was conducted to obtain user feedback and to assess the usefulness of the developed application by providing an evaluation questionnaire containing questions related to application usage. In SUS testing, a Likert scale is used as the measurement scale, consisting of the following options: "Strongly Disagree (1)," "Disagree (2)," "Neutral (3)," "Agree (4)," and "Strongly Agree (5)" [16].

d. User Experience Questionnaire

User Experience Questionnaire (UEQ) testing was conducted to measure users' experiences after using the application and to provide an evaluation across six variables: Attractiveness, Perspicuity, Efficiency, Dependability, Stimulation, and Novelty. The UEQ method involves 26 items or statements completed by respondents. Each response is transformed using the UEQ data analysis tool, after which the mean values are calculated. The final process involves comparing the mean values and variance (impression scores) with evaluation benchmarks, where impression values between –0.8 and 0.8 indicate normal evaluation results. Impression values greater than 0.8 indicate positive evaluation results, while impression values less than –0.8 indicate negative evaluation results [17].

3. Results and Discussion

4.1. Black-Box Testing

Before the application was distributed to students, functional testing was conducted using black-box testing. Blackbox testing showed that there were no errors in the application and successfully demonstrated that all functional requirements within the system were tested.

4.2. Testing

Testing was conducted in two stages: a pretest to measure students' initial knowledge before using the application, and a posttest conducted after the application was used. The results of the average score calculations obtained from five test sessions are presented in the graph shown in Figure 8.

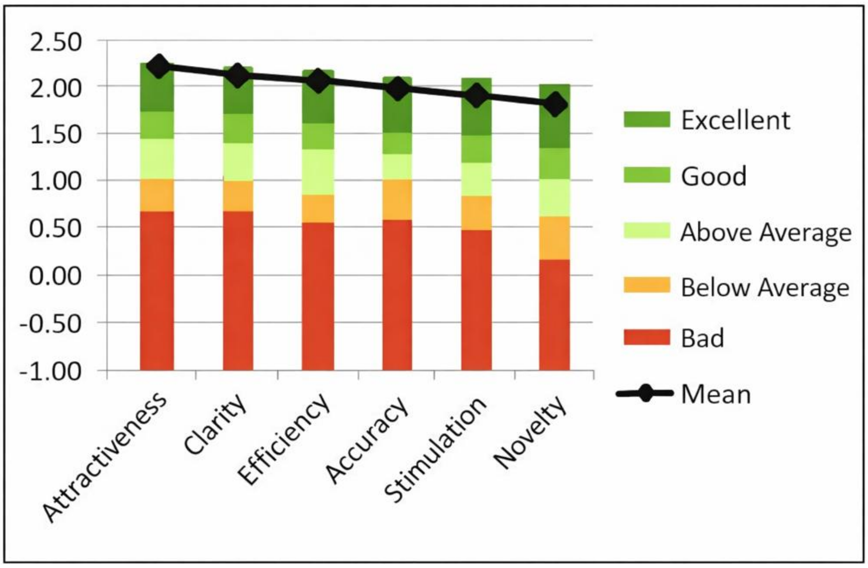

Figure 8. Average Pretest and Posttest Scores in English of 30 Third-Grade Students at Madrasah Ibtidaiyah Swasta Karya Thayyibah LIMRAN

The average scores were then used to calculate the percentage of improvement in order to determine the effect of the augmented reality learning media on the English learning outcomes of third-grade students at MIS KT LIMRAN, using the following formula [18].

Based on the results of the percentage change calculations, there was an improvement in scores in each test. In the first test, the score increased by 42%; in the second test, by 15%; in the third test, by 9%; in the fourth test, by 2%; and in the fifth test, by 1%. The average score graph shown in Figure 9 also illustrates an increase in scores across all tests. For example, the average score in the first pretest was 45, while the posttest score increased to 65. In the final test, the pretest score was 97, and the posttest score increased to 98.

4.3. System Usability Scale

Next, testing was conducted using the System Usability Scale (SUS) method to determine user responses and the success of the application. The results of the SUS testing are presented in Table 2. After calculating the total SUS score obtained from the evaluation questionnaires, a total score of 2,740 was achieved. The next step was to calculate the average score by dividing this total score by the number of respondents.

$$Average\ Score = \frac{Total\ Score}{Number\ of\ Respondens}$$

$$= \frac{2740}{30} = 91$$

Thus, the calculation results show that the average score obtained from 30 respondents is 91.

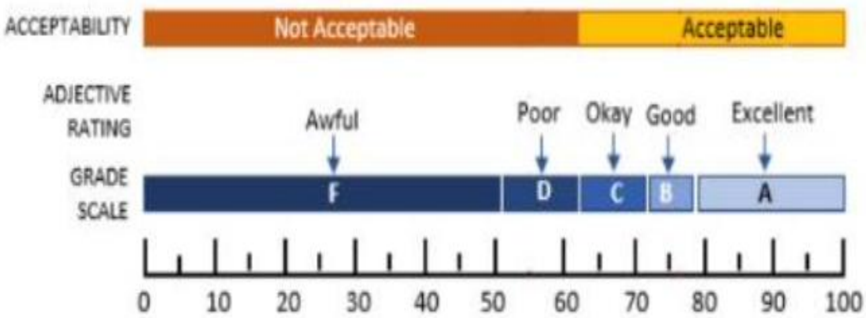

Figure 9. System Usability Scale Scoring Criteria

Based on Figure 9, the application falls into the "Acceptable" category, indicating that it is well accepted from the users' perspective. On the Grade Scale, the application is classified as Grade A, while on the Adjective Ratings parameter, the application is rated as "Excellent" or "Very Good." This result implies that the application provides a learning environment that is easy to use, efficient, and engaging, which supports students' focus during the learning process. High usability reduces cognitive load, allowing learners to concentrate more on understanding the learning content rather than on operating the system. Consequently, the application has strong potential to positively influence learning effectiveness and improve learning outcomes, as students can interact with the material more comfortably, actively, and meaningfully.

4.4. User Experience Questionnaire

Next, students' learning experiences using the augmented reality–based learning media were measured using the User Experience Questionnaire (UEQ). Each respondent's answers were transformed using the UEQ Data Analysis Tool. The weighted values were then analyzed using the mean, variance, and standard deviation. The final process involved analyzing the mean and variance values for each category group, namely attractiveness, perspicuity, efficiency, dependability, stimulation, and novelty. The results of the mean and variance analysis for these six categories are presented.

The calculated mean and variance values indicate positive impression scores for all categories, as shown by the upward green arrows. Each category achieved an impression value above 0.8, with the lowest score being 2.033 for the novelty category and the highest score being 2.439 for the attractiveness category. The data are then presented in a benchmark graph shown in Figure 10.

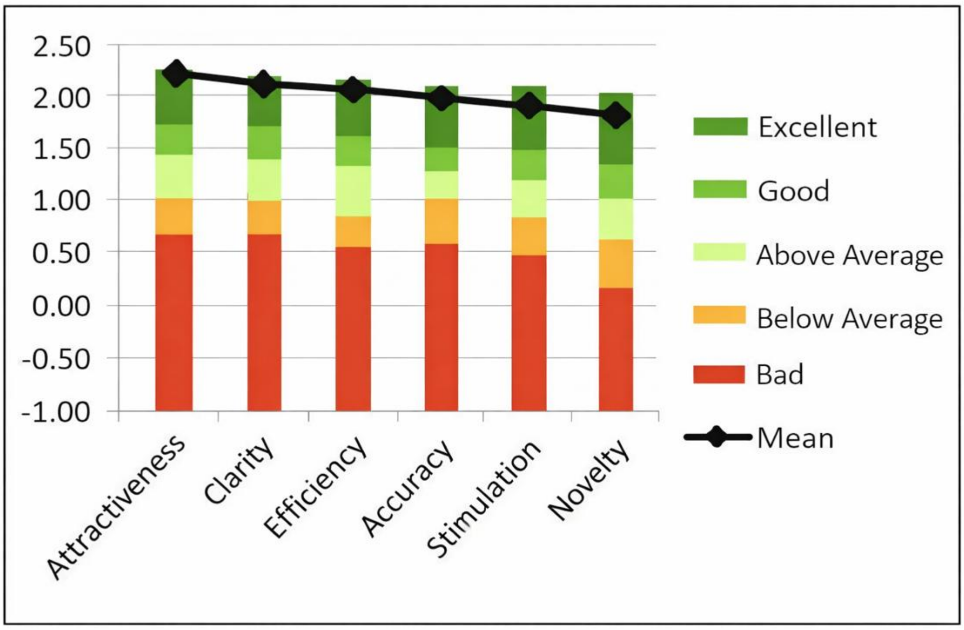

Figure 10. UEQ Benchmark Graph

4. Conclusion

This study successfully developed and evaluated an augmented reality–based English learning medium using a markerless target tracking model approach. The experimental results demonstrate that the proposed learning media effectively improves students' English vocabulary learning outcomes, as evidenced by consistent increases in pretest–posttest scores across multiple testing sessions. These findings indicate that augmented reality can serve as an engaging and effective learning tool for elementary-level English education. In terms of system quality, usability testing using the System Usability Scale yielded a high average score, indicating excellent usability and strong user acceptance. Furthermore, user experience evaluation using the User Experience Questionnaire showed positive impressions across all measured dimensions, including attractiveness, efficiency, dependability, stimulation, and novelty. These results suggest that the developed application not only supports learning effectiveness but also provides a positive and enjoyable learning experience for students.

Overall, the augmented reality–based English learning media using a target tracking model demonstrates strong potential as an innovative instructional tool. Future research may expand the learning content, improve object recognition accuracy, and optimize target tracking performance to further enhance learning effectiveness and application scalability in broader educational contexts

Author Contributions Statement

Gunawan Mulyadi conceptualized the study, designed the research methodology, and led the development of the augmented reality learning media using the target tracking model approach. He also supervised the overall research process and contributed to the writing and revision of the manuscript. Rizka Ardiansyah was responsible for system implementation, augmented reality development, and technical testing, including blackbox testing and system evaluation. Hajra Rasmita contributed to the instructional design, learning content development, data collection, and analysis of learning outcomes. All authors reviewed, revised, and approved the final manuscript.

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