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An Augmented Reality-Based Introduction to Basic Electronic Components Utilizing Android

Karno Diantoro[1], Corizon Sinar Arainy[2], Rinaldo[3], Abdur Rohman[4]
STMIK Mercusuar, Indonesia[1234]
Correspondent: karno@mercusuar.ac.id [1]

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ABSTRACT: The widespread use of smartphones and the development of augmented reality (AR) technology have created new opportunities for creative teaching methods. This study investigates how students studying fundamental electronic components could benefit from adopting augmented reality (AR) on Android devices. The research uses a user-centred design methodology that includes cycles of user testing and iterative prototyping. The Vuforia AR Software Development Kit (SDK) and Unity game engine are used to develop the AR application, which uses computer vision techniques for object tracking and recognition. The application includes interactive simulations, explanatory content designed for instructional purposes, and 3D models of electronic components. We will gather quantitative and qualitative data via questionnaires, user feedback sessions, and pre- and post-tests. To assess how well the AR application improves students' comprehension and recall of the material, statistical analytic techniques like t-tests and ANOVA will be used. In addition, qualitative data will undergo theme analysis to learn more about user experience, engagement, and possible areas for development. The main objective of this project is to create an augmented reality application that can teach students the principles of electronic components understandably and effectively. The program seeks to enhance engagement, comprehension, and recall of the subject matter by utilizing augmented reality's immersive and interactive qualities.

Keywords: Augmented Reality (AR), Marker, Android, 3D, Electronic Components

INTRODUCTION

Studying basic electrical components is fundamental to many technological and engineering fields. Nevertheless, students frequently struggle to understand these components' abstract ideas and practical applications while learning through traditional teaching techniques(Carmigniani et al., 2011; Challenor & Ma, 2019). It can be difficult for many students to comprehend electronic components' complex features and workings just by listening to lectures or reading textbooks.

Several studies have emphasized the potential advantages of using immersive and interactive technology in educational contexts, including augmented reality (AR)(Aditama et al., 2021; Hanid et al., 2020). AR makes it possible to superimpose digital content in the real environment, resulting in a distinctive educational opportunity that can improve comprehension, retention, and engagement (Azuma, 1997; Billinghurst & Duenser, 2012).

Previous research has shown that augmented reality is successful in various educational settings. For example, Shelton and Hedley (2002) discovered that augmented reality (AR)-based learning experiences increased student interest and participation in a geology course. Similarly, Núñez et al. (2008) documented successful results when utilizing augmented reality (AR) in chemistry teaching to visualize and comprehend complex molecular structures(Al-Ansi et al., 2023; Elmqaddem, 2019).

Although augmented reality (AR) has great promise for education, its use in teaching fundamental electronic components is still largely unexplored(Uriarte-Portillo et al., 2023; Voinea et al., 2023). This gap offers a chance to use AR's immersive and interactive qualities to improve students' comprehension of electronic components and their learning process.

Research Issues

1) How well does an augmented reality-based application help students comprehend and remember fundamental electronic components compared to conventional teaching techniques?
2) How do students who use an augmented reality application to learn about basic electronic components perceive and experience it?

Goals of the Research

1) To create an augmented reality application for Android devices that introduces and explains fundamental electronic components(Volioti et al., 2022).
2) To assess how well the augmented reality-based program has improved pupils' comprehension and memorization of fundamental electronic components(Kamińska et al., 2023).
3) Investigate how students view, interact with, and use the augmented reality-based application to learn about fundamental electronic components.

Idea Structure

This study's conceptual framework aims to improve students' understanding of fundamental electronic components by fusing augmented reality technology with instructional principles. The following are the framework's main elements:

1) Augmented Reality Technology: The study will use augmented reality (AR) technology to create an engaging and dynamic learning environment. With AR, students can view and interact with electronic components in a new way by superimposing digital information, including 3D models, animations, and instructional text, onto the real world.
2) Educational Principles: Well-established educational tenets, including constructivism, active learning, and multimedia learning theory, will inform the creation and execution of the augmented reality application(Arjoni et al., 2023; Arslan et al., 2020). These concepts stress the value of interactive experiences, hands-on exploration, and integrating many modalities (visual and aural) to improve learning and memory.

3) User Experience and Engagement: The study aims to give students an easy-to-use and interesting augmented reality experience. Factors like gamification components, smooth integration of augmented reality information, and intuitive interface design will be considered to keep students interested and motivated throughout the learning process(Abdul Hanid et al., 2022; Alp et al., 2023).
4) Evaluation & Assessment: To assess the efficacy of the AR-based application, a combination of quantitative measurements (pre-and post-tests, performance assessments) and qualitative methods (surveys, interviews, observations) will be used. This multifaceted strategy will show how it affects students' comprehension, recall, and general learning process.

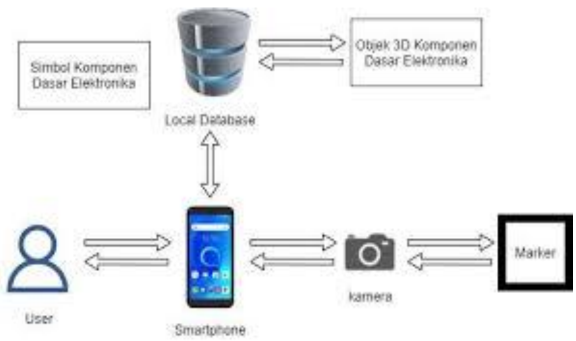
The conceptual framework seeks to close the knowledge gap between conventional teaching techniques and cutting-edge technologically enhanced learning opportunities, eventually helping students gain a deeper comprehension and appreciation of fundamental electronic components(Taghian et al., 2023).

METHOD

Design of Research

This study will use a mixed-methods research design, integrating quantitative and qualitative techniques. The qualitative component will investigate students' perspectives and experiences using the program. In contrast, the quantitative component will use a quasi-experimental methodology to assess the efficacy of the AR-based application.

Figure 1. Design of Research



(JITSI: Scientific Journal of Information Systems Technology, Volume 2 No 4, December 2021 Pages 134 - 140)

Attendees and Samples

The study will involve undergraduate students at a particular university who are enrolled in electrical engineering or similar areas. To find volunteers, convenience sampling will be employed. A statistical power analysis will be used to establish the sample size to guarantee sufficient representation and the generalizability of the results.

Figure 2. Attendees and Samples

(Augmented reality learning environment to aid engineering students in performing practical laboratory experiments in electronics engineering)

Methods for Gathering Data

1. Numerical Information
   - Pre- and post-test assessments: To gauge participants' comprehension and memory of fundamental electronic components, tests will be administered before and after using the AR-based application.
   - Performance assessments: Realistic activities or electronic components simulations will assess students' applied knowledge and abilities.
2. Qualitative Data
   - Surveys: Surveys will be administered to gather input on participants' opinions, experiences, and general satisfaction with the AR-based application. Semi-structured interviews: A subset of participants will be interviewed to obtain detailed insights into their experiences, difficulties, and recommendations for improvement.
   - Observation: While participants engage with the augmented reality program, researchers will watch them and record their actions, responses, and degrees of involvement.

Methods of Data Analysis

1. Metric Evaluation
   - Descriptive statistics: Central tendency and variability measures will be computed for the pre-, post-, and performance assessment scores.
   - Statistics that infer: Repeated measurements or paired t-tests To compare pre-test and post-test results and assess how the AR-based application affected students' comprehension and retention, an ANOVA will be performed. Effect size computations: Cohen's d or eta-squared will be performed to estimate the size of the observed effects.
2. Evaluative Study
   - Thematic analysis: To find recurrent themes, patterns, and insights into students' perspectives and experiences, thematic analysis techniques will be applied to survey responses, interview transcripts, and observation notes.

- Triangulation: To strengthen the validity and trustworthiness of the qualitative results, information from several data sources (such as surveys, interviews, and observations) will be combined.

Methods of Analysis

In this investigation, the following software and analytical tools will be used:

- Software for statistical analysis of quantitative data, such as R or SPSS, which includes both descriptive and inferential statistics.
- Software for organizing, coding, and analyzing qualitative data from surveys, interviews, and observations (e.g., NVivo, MAXQDA).
- AR development frameworks and tools (such as Unity and Vuforia) for designing and constructing AR applications.
- Tools for presentations and visuals (like Prezi and Microsoft PowerPoint) to effectively convey study findings.

With mixed-methodologies research, which integrates quantitative and qualitative methods, a thorough understanding of the efficacy and influence of the augmented reality-based application on students' acquisition of fundamental electronic components will be possible.

Summary and Phases of the Study

Overview: Using Augmented Reality (AR) technology, the project attempts to create an Android-based application that exposes fundamental electronic components. The program uses augmented reality (AR) to turn regular photos of electronic components into interactive 3D visual representations. This creative method improves the educational process and fosters a more profound comprehension of electronic components' applications, functions, and architectures.

Phases of the Study:

1. Requirement Analysis:
   - Carefully examine students' educational requirements and obstacles when studying electronics fundamentals.
   - Determine the intended user base and the features and functionalities of the application by identifying the target audience and getting input from educators and students.
   - Specify the project's parameters, such as the electronic components that must be included and the necessary degree of detail for each.

2. Design and Modeling:
   - Make precise and in-depth 3D models of the chosen electronic components using 3D modelling software like Blender(Um et al., 2023).
   - Create the application's user interface (UI) and user experience (UX) with easy-to-use navigation, lucid visuals, and smooth augmented reality integration in mind.

- Create prototypes and wireframes to assess and improve the design before execution.

3. AR Implementation:
   - To integrate the 3D models into the AR world, select a suitable AR framework or SDK, such as Unity 3D with Vuforia, ARCore, or ARKit.
   - Use marker-based or markerless augmented reality techniques to make 3D component models appear when the camera is aimed at particular objects or surfaces.
   - Include interactive elements, such as the ability to rotate, zoom, and manipulate 3D models, to create a fully immersive learning environment.

4. Application Development:
   - Create the Android application using your chosen frameworks and programming languages. For Android development, use Java or Kotlin.
   - Integrate the AR capabilities with the user interface to ensure a smooth transition between the AR elements and the program's functions.
   - Include extra features to improve the learning process, such as interactive simulations, lessons, or quizzes.

5. Testing and Evaluation:
   - To guarantee a dependable and seamless user experience, thoroughly test the application, including functional, usability, and performance testing.
   - Get input from users, instructors, and subject matter experts on the app's efficacy in assisting students in understanding fundamental electronic components(Morales et al., 2022).
   - Examine the comments and modify or enhance the application in light of the evaluation's findings.

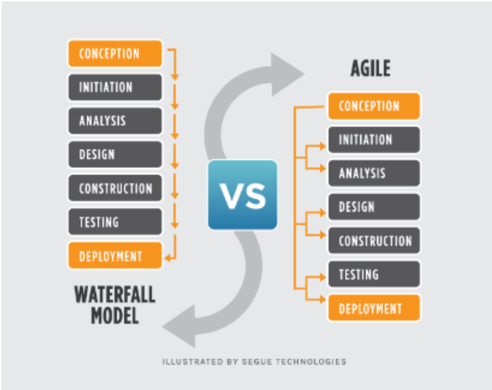
6. Deployment and Dissemination:
   For broad availability, deploy the application to the Google Play Store or other distribution channels.
   - Promote the application through relevant channels, online groups, and educational institutions to reach the target audience(Nistrina, 2021; Paredes-Velasco et al., 2023).
   - Respond to user input and changing educational requirements by offering assistance, documentation, and prospective upgrades or modifications(Mozaffari & Hamidi, 2023; Munzer et al., 2019).

Adhering to optimal methodologies in software development, user-centred design, and educational technology principles during the research phase is imperative to guarantee the construction of a superior, efficient, and captivating educational tool(Perifanou et al., 2023). For the development of the "Android-Based Introduction to Basic Electronics Components Using Augmented Reality" application, the following methods will be used:

1) Application Development Methods:

- Waterfall Method: This method involves sequential stages, such as requirement analysis, system design, implementation, testing, and maintenance(Rebollo et al., 2022).
- Agile Method: This method involves iterative and incremental development, where the application is developed in several cycles, with continuous feedback and adjustments(Pinto et al., 2022).

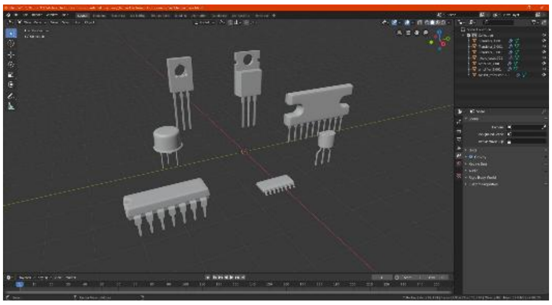
Figure 3 Waterfall and Agile Method



(https://www.seguetech.com/waterfall-vs-agile-methodology/)

2) 3D Modeling Software:
- Blender: Using the Blender software to create 3D models of essential electronic components(Rizki et al., 2023; Sadamali Jayawardena et al., 2023).
- 3D Max or Maya: Alternative 3D modeling software that can create 3D models of electronic components(Saleem et al., 2023).

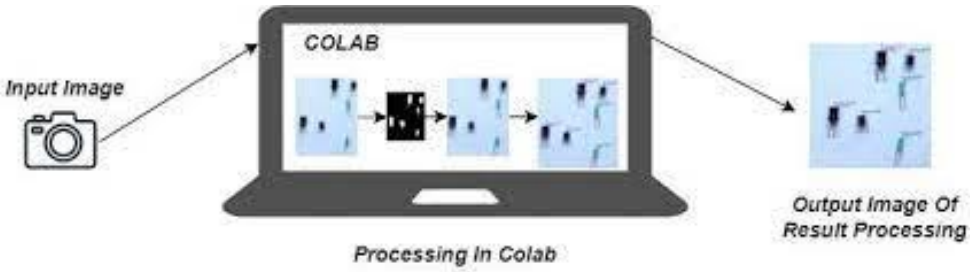
Figure 4.Blender software 3D models of essential electronic components



(https://free3d.com/3d-model/active-electronics-components-set-6241.html)

3) Augmented Reality (AR) Implementation(Ali et al., 2023):
- Unity 3D with Vuforia: This integration of 3D models into the AR environment uses Unity 3D as the game engine and Vuforia as the AR SDK(Grubert et al., 2017).
- ARCore or ARKit: Using the built-in AR frameworks from Android (ARCore) or iOS (ARKit) to implement AR features in the application(Hanid et al., 2022).

Figure 5 Augmented Reality (AR) Implementation(Rahmat et al., 2023)



(e-Proceedings of Applied Science: Vol.9, No.1 February 2023)

4) User Interface (UI/UX) Development:
   - Responsive Design: Designing a responsive user interface that can adapt to various screen sizes of Android devices(Huang et al., 2018).
   - Material Design Principles: Following Google's material design principles to create an intuitive and visually appealing interface(Marini et al., 2022; Molnár et al., 2018).

5) Testing:
   - Unit Testing: Testing each component or module of the application separately to ensure proper functionality(López-Belmonte et al., 2023).
   - Integration Testing: Testing the interaction between various components or modules of the application to ensure compatibility and proper integration(Ibáñez & Delgado-Kloos, 2018).
   - User Acceptance Testing: Involving end-users in the testing process to obtain feedback and assess the application's usability and user experience(Jayawardena et al., 2023; Jeffri & Awang Rambli, 2021).

RESULT AND DISCUSSION

System Design

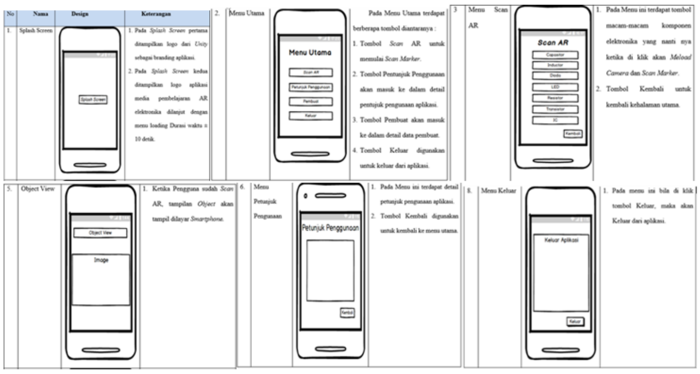
1. System Architecture
   - Explain the high-level system architecture's principal elements and how they interact.
   - Describe the selected software development methodology (e.g., multi-tier, client-server, or monolithic)(Arena et al., 2022).
   - Provide an architectural diagram showing the relationships between the various parts of the system.

Figure 6. System Architecture

2. User Interface Design
   - Talk about the rules and criteria for user interface (UI) design that were adhered to throughout development.
   - Explain the design, layout, and navigation patterns that were selected.

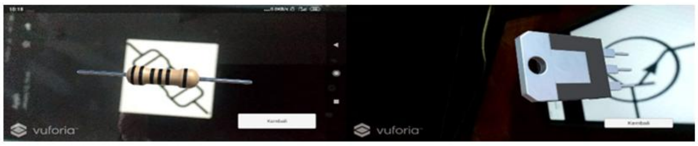
- Use mockups or wireframes to illustrate the desired user experience.

Figure 7. User Interface Design



3. Integrating Augmented Reality with 3D Modeling
   - Explain how Blender or other software is used to create 3D models of the electronic components.
   - Describe the methods and resources utilized to incorporate the 3D models into the augmented reality (AR) setting.
   - Talk about the application's marker-based or markerless augmented reality strategy.

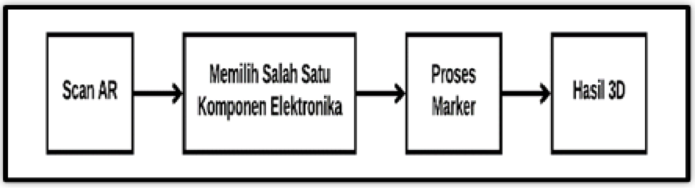
Figure 8. User Interface Design Integrating Augmented Reality with 3D Modeling



System Evaluation

The output displays from the AR application for introducing electronic components are shown in the system analysis that follows:

Figure 9. System Evaluation



Testing Systems on Smartphones

Black Box Testing, which focuses on the functional requirements of the software, is the method used to test the recently constructed system. The Black Box Testing for the AR Application to Introduce Electronic Components is as follows.

Table 1. AR Scan Menu Testing

No	Scenario Testing	Form Testing	The Results Expected	Process	Conclusion
1.	Button Testing Capacitor	Click Capacitor	Will load cameras for scan markers	Success	In accordance
	Button Testing Capacitor	Click Inductor	Will load cameras for scan markers	No Success	No In accordance
2.	Button Testing Inductors	Click Inductor	Will load cameras for scan markers	Success	In accordance
	Button Testing Inductors	Click Diode	Will load cameras for scan markers	No Success	No In accordance
3.	Button Testing Diode	Click Diode	Will load cameras for scan markers	Success	In accordance
	Button Testing Diode	Click IC	Will load cameras for scan markers	No Success	No In accordance
4.	Button Testing IC	Click IC	Will load cameras for scan markers	Success	In accordance
	Button Testing IC	Click LED	Will load cameras for scan markers	No Success	No In accordance
5.	Button Testing LED	Click LED	Will load cameras for scan markers	Success	In accordance
	Button Testing LED	Click Resistor	Will load cameras for scan markers	No Success	No In accordance
6.	Button Testing Resistor	Click Resistor	Will load cameras for scan markers	Success	In accordance
	Button Testing Resistor	Click Transistor	Will load cameras for scan markers	No Success	No In accordance
7.	Button Testing Transistor	Click Transistor	Will load cameras for scan markers	Success	In accordance
	Button Testing Transistor	Click Capacitor	Will load cameras for scan markers	No Success	No In accordance

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CONCLUSION

This study describes a creative way to use Augmented Reality (AR) technology to introduce essential electronic components on the Android platform(Rukayah et al., 2022). This approach aims to enhance students' learning experience by providing an immersive and interactive environment that enables them to perceive and understand the functioning of electronic components(Sutherland et al., 2019). The proposed solution offers educational institutions and consumers interested in electronics education an accessible and reasonably priced option by utilizing augmented reality (AR) and the widespread availability of Android devices. Students can study and comprehend electronic components through hands-on activities when augmented reality (AR) is integrated into the Android platform. This can enhance student engagement and retention and the entire learning process(Syed et al., 2023; Tagaytayan et al., 2018). This augmented reality approach demonstrates how cutting-edge technology may revolutionize traditional teaching methods and adapt to the evolving demands of modern pupils"(Fernández-Enríquez & Delgado-Martín, 2020; Gudoniene & Rutkauskiene, 2019).

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