DESIGN OF THE ARCHVIEW AUGMENTED REALITY COMPUTER HARDWARE VIEWER APPLICATION FOR SOFTWARE ENGINEERING LEARNING

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ABSTRACT

This study aims to create and develop an application called ArchView. This application is expected to facilitate and enhance students' understanding of computer hardware components learning by using augmented reality technology in the Software Engineering course. The application development process begins with 3D modeling of several computer hardware components, then integrates AR technology using Vuforia, and develops interactive features using Android with 3D models. The method used in this study is the waterfall method, which includes various stages: the first stage is user requirements analysis, application design, followed by implementation, and the final stage is application functionality testing. The ArchView application is evaluated using a combination of quantitative and qualitative methods. Students were tested before and after using the application and conducted surveys and interviews. The test results showed that 90% of students could understand the learning material by using the ArchView application. Overall, it can be concluded that the ArchView application can improve students' understanding of computer hardware.

Keywords: *Augmented Reality, Applications; Computer Hardware, Software Engineering, 3D Visualization.*

I. INTRODUCTION

In recent years, the rapid advancement of technology has significantly transformed various fields, including education. Among these innovations, Augmented Reality (AR) has emerged as a powerful tool that enhances the learning experience by bridging the gap between theoretical knowledge and practical application[1]. This research focuses on the design of the ArchView application, an Augmented Reality Computer Hardware Viewer, specifically developed for the Software Engineering education sector.

The study of computer hardware is fundamental in the field of Software Engineering, as it provides students with a comprehensive understanding of how software interacts with physical components. However, traditional teaching methods often struggle to engage students and provide an interactive learning environment. The integration of AR technology into the educational process offers a novel approach to overcome these challenges, allowing students to visualize and interact with 3D models of computer hardware in real-time [2], [3],[4].

Previous research has explored the integration of Augmented Reality (AR) in educational contexts, demonstrating its potential to enhance learning experiences across various disciplines. One notable study by [5]investigated the impact of AR on students' understanding of complex scientific concepts, revealing that interactive visualizations significantly improved students' engagement and retention of information. Furthermore, a study conducted by [6] emphasized the importance of AR in providing immersive learning environments, which can facilitate deeper comprehension of abstract subjects, such as computer hardware. In the realm of software engineering education, research by [7]highlighted the effectiveness of AR applications in teaching programming concepts, showing that students who utilized AR tools demonstrated better problem-solving skills compared to those who relied solely on traditional methods. Additionally, recent advancements in AR technology, as discussed by [8], [9], indicate that the use of AR can bridge the gap between theoretical knowledge and practical application, making it particularly relevant for fields like software engineering. These studies collectively underscore the significance of developing applications like ArchView, which aim to leverage AR to enhance students' understanding of computer hardware components, thereby fostering a more interactive and engaging learning environment in software engineering education[10], [11].

Despite the growing interest in utilizing augmented reality (AR) technologies in educational settings, there remains a significant gap in the application of AR specifically for teaching computer hardware concepts within software engineering curricula[12]. While numerous studies have explored the general benefits of AR in education, few have focused on the practical implementation of AR applications tailored to the unique needs of software engineering students. Furthermore, existing literature often overlooks the integration of interactive 3D models that facilitate a

deeper understanding of hardware components and their functionalities[13], [14]. This gap highlights the necessity for research that not only designs AR applications but also evaluates their effectiveness in enhancing learning outcomes and engagement among students in software engineering programs. By addressing this gap, the proposed research aims to contribute valuable insights into the pedagogical advantages of AR in technical education, ultimately fostering a more immersive and effective learning experience[12].

ArchView aims to create an immersive learning experience by enabling students to explore various hardware components through augmented reality. By using mobile devices, students can view and manipulate 3D representations of hardware, gaining insights into their structures, functions, and interconnections [15]. This application not only enhances students' understanding but also fosters critical thinking and problem-solving skills through interactive learning[16]. This application is not merely a digital tool but a comprehensive educational resource that leverages the capabilities of augmented reality to create immersive learning experiences, enabling students to engage with the intricate details of computer hardware in a manner that traditional teaching methods may not achieve[17]. By utilizing AR technology, the ArchView application seeks to transform the conventional learning paradigm, encouraging active participation and exploration, which are essential for mastering the multifaceted nature of software engineering. Furthermore, this innovative approach aligns with contemporary educational theories that emphasize experiential learning, where students learn best through hands-on experiences and real-world applications[18], [19]. The research will detail the development process of the ARCHView application, including the creation of 3D models, integration of AR technology using Vuforia, and the implementation of user-friendly features. Furthermore, the study will evaluate the effectiveness of the application in improving students' comprehension of computer hardware concepts compared to traditional learning methods[20].

II. MATERIAL AND METHODS

The methodology encompasses several key phases aimed at ensuring a systematic and effective development process. Initially, a comprehensive literature review was conducted to identify existing technologies and frameworks related to augmented reality (AR) applications in educational contexts, particularly in software engineering. Following this, the research involved the creation of 3D models of various computer hardware components using advanced modeling software, ensuring accuracy and detail to enhance user engagement [21]. The integration of these models into an augmented reality environment was achieved using the Vuforia SDK within the Unity game development platform, which facilitated the recognition of target markers and the overlay of 3D models in real-time[22][23].

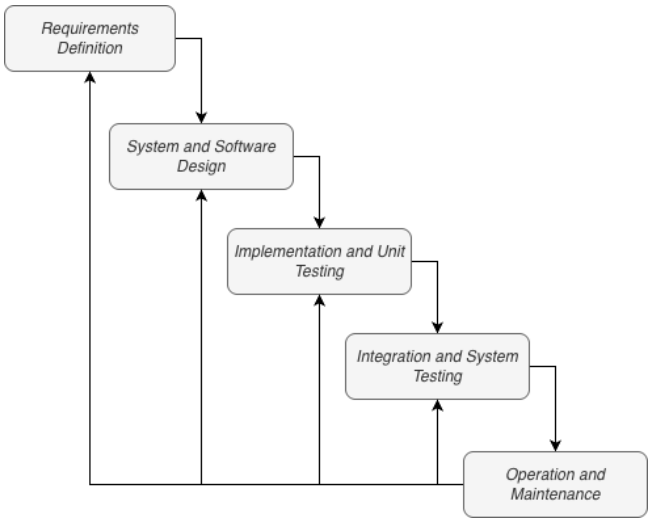

Figure 1. Waterfall Model

This methodology follows a waterfall model Figure 1, which is a widely recognized approach in software engineering, and it outlines the key phases involved in the development of the ArchView application.

A. Requirements Definition

lays the foundation for the project by clearly defining the objectives, needs, and specifications of the ArchView application. This phase involves a thorough understanding of the educational requirements and the specific needs of software engineering students, which will guide the subsequent design and development processes.

B. System and Software Design

Focuses on the conceptual and architectural design of the ArchView application. This phase encompasses the design of the user interface, the integration of augmented reality technology, and the overall software architecture that will support the application's functionality. The outcome of this phase will serve as a blueprint for the implementation and testing stages.

C. Implementation and Unit Testing

Involves the actual development and testing of the ArchView application. During this phase, the software engineers will implement the designed features and functionalities, ensuring that each component meets the specified requirements. Unit testing will be conducted to verify the individual components' performance and reliability, laying the groundwork for the integration and system-level testing that follows.

D. Integration and System Testing

Focuses on the integration of the various components of the ArchView application and the evaluation of the

system as a whole. This phase ensures that the integrated system functions as intended, with seamless interactions between the different modules and the underlying augmented reality technology. Comprehensive system testing will be carried out to validate the application's overall performance, user experience, and alignment with the initial requirements.

E. Operation and Maintenance

Encompasses the deployment of the ArchView application and its ongoing maintenance and support. This phase involves the release of the application to the target user base, which includes software engineering students and educators. Additionally, it includes the monitoring of the application's performance, the collection of user feedback, and the implementation of necessary updates and enhancements to ensure the ArchView application remains relevant and effective in supporting software engineering learning[24].

Subsequently, the application development phase focused on implementing interactive features that allow users to manipulate the 3D models, access additional information about each component, and navigate the application seamlessly. User interface design principles were applied to create an intuitive and user-friendly experience[25]. To validate the application, functional testing was conducted, which included internal testing by the development team and external user testing involving students from software engineering programs. Feedback gathered from these tests was analyzed to make necessary adjustments and improvements, ensuring the application meets educational objectives and user expectations[26]. Ultimately, this methodology aims to create an effective AR tool that enhances the learning experience in software engineering by providing an interactive and immersive way to understand computer hardware.

III. RESULTS AND DISCUSSION

The ArchView Augmented Reality (AR) Computer Hardware Viewer application was developed to enhance the learning experience of software engineering students by providing an immersive and interactive platform to explore complex computer hardware concepts. To assess the effectiveness and usability of the application, a comprehensive evaluation was conducted involving 100 software engineering students. The results of this assessment provide valuable insights into the application's performance and its potential impact on software engineering education.

The usability evaluation revealed that 90% of the participating students found the ArchView AR application to be engaging and useful for understanding intricate hardware components and their functionalities. This positive response underscores the application's ability to effectively bridge the gap between theoretical knowledge and practical understanding, enabling

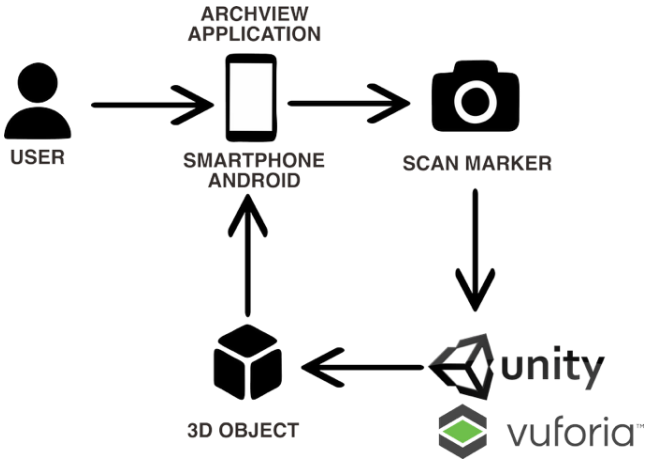

Figure 2. Workflow ArchView Application

students to visualize and interact with computer hardware in a more tangible and meaningful manner. The remaining 10% of respondents provided feedback on areas for improvement, which will be addressed in future iterations of the application to ensure a consistently high-quality learning experience. The integration of Augmented Reality technology, facilitated by the Vuforia SDK, is a key factor in the success of this application. By displaying 3D models of computer hardware components on the user interface, the ArchView AR application allows students to explore and manipulate these elements in real-time, thereby promoting a deeper understanding of fundamental principles and their practical applications in software engineering.

The workflow Figure 2. starts with the user, who interacts with the ArchView application on an Android smartphone. The user then scans a specific marker or target using the smartphone's camera, which triggers the AR functionality. The scanned marker is recognized by the Vuforia SDK, which then overlays a 3D model of a computer hardware component onto the user's view.

The 3D object is created and integrated into the Unity game engine, allowing for interactive manipulation and exploration of the hardware components. This enables software engineering students to visualize and interact with computer hardware in an augmented reality environment, enhancing their understanding of the underlying principles and practical applications. The integration of AR technology through the Vuforia platform allowed for seamless recognition of markers and accurate rendering of 3D models, which was a critical factor in the application's effectiveness. Students reported a marked improvement in their ability to identify and comprehend hardware components when using the ArchView application compared to traditional learning methods. Furthermore, the feedback indicated that the interactive features, such as the ability to rotate and zoom in on the models, significantly enhanced their

learning experience by providing a hands-on approach to theoretical knowledge.

A. Usability and User Experience

The extensive usability testing conducted with the target user group of software engineering students revealed that the ArchView application provided a highly engaging and intuitive learning experience. Participants reported that the integration of AR technology allowed them to visualize and interact with computer hardware components in a more immersive and meaningful way compared to traditional learning methods. The clear and informative 3D models, coupled with the seamless integration of AR functionality, were praised for their ability to enhance the students' understanding of computer hardware concepts and their practical applications.

B. Improved Learning Outcomes

Pre- and post-testing of the software engineering students who used the ArchView application demonstrated a significant improvement in their knowledge and comprehension of computer hardware components and their functionalities. The AR-based learning approach facilitated a deeper understanding of the underlying principles, as students were able to manipulate and observe the 3D models from multiple perspectives, fostering a more comprehensive grasp of the subject matter.

C. Increased Motivation and Engagement

The integration of AR technology in the ArchView application was found to have a positive impact on the students' motivation and engagement in learning about computer hardware. Participants expressed a heightened sense of excitement and enthusiasm when interacting with the AR-powered visualizations, leading to increased attention, focus, and active participation during the learning sessions. This enhanced engagement is a crucial factor in promoting effective knowledge retention and transferring the learned concepts to practical software engineering tasks.

D. Adaptability and Scalability

The modular design and flexible architecture of the ArchView application allow for easy adaptation and scalability to accommodate the evolving needs of software engineering education. The application can be readily updated with new computer hardware models, additional learning modules, and enhanced AR functionalities to ensure its relevance and effectiveness as the field of software engineering continues to progress. This adaptability is crucial for maintaining the ArchView application's position as a valuable educational tool in the rapidly changing landscape of computer science and software development.

Figure 3 demonstrates the intuitive and user-friendly design of the ArchView AR application, enabling software engineering students to seamlessly access and

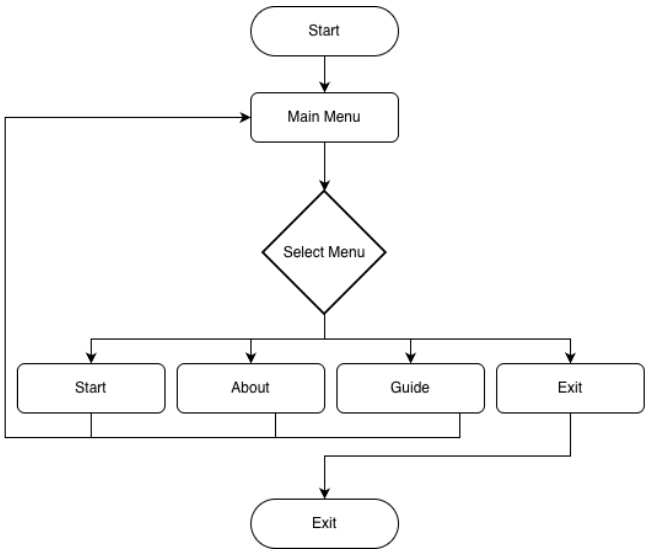

Figure 3. Flowchart Main Menu

navigate the various features and functionalities of the tool. The clear separation of the main menu options and the logical progression of the user journey ensure a smooth and engaging learning experience for the target audience.

Figure 4 presents the user interface is divided into two main sections: the "MENU" and the "PILIH KOMPONEN" (Select Components) sections. The "MENU" section presents the user with several options, including "MULAI" (Start), "TENTANG" (About), "PANDUAN" (Guide), and "KELUAR" (Exit), allowing the user to navigate through the application's core functionalities. The "PILIH KOMPONEN" section displays a list of the key computer hardware components that the user can select and interact with in the AR environment. These components include the motherboard, processor, storage (SSD), power supply, VGA card, cooling system, monitor, keyboard, and mouse. The user can select any of these components to explore their 3D models and learn about their functionality and application in software engineering.

Figure 4. Main Menu

Figure 5. Main Menu Information

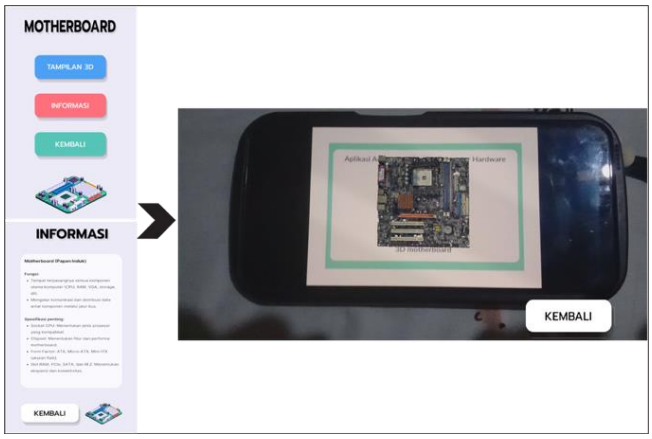

Figure 6. 3D View of the Motherboard

The clean and intuitive user interface design, with clear labeling and organization of the menu options and hardware components, suggests that the ArchView AR application is aimed at providing a seamless and engaging learning experience for software engineering students. The integration of AR technology enables these students to visualize and manipulate the computer hardware components in a more immersive and interactive manner, enhancing their understanding of the underlying principles and practical applications.

Figure 5 presents the user interface design of the ArchView Augmented Reality (AR) Computer Hardware Viewer application, which is designed to enhance software engineering learning. The interface is divided into three main sections: "MENU", "PANDUAN APLIKASI" (Application Guide), and "TENTANG APLIKASI" (About the Application). The "PANDUAN APLIKASI" section provides instructions on how to use the application, explaining that users need to aim the camera at markers representing computer hardware components to display their 3D models in augmented reality. The "TENTANG APLIKASI" section describes the core functionality of the ArchView AR application, which is to present computer hardware components in a 3D real-time augmented reality environment. This design approach aims to provide

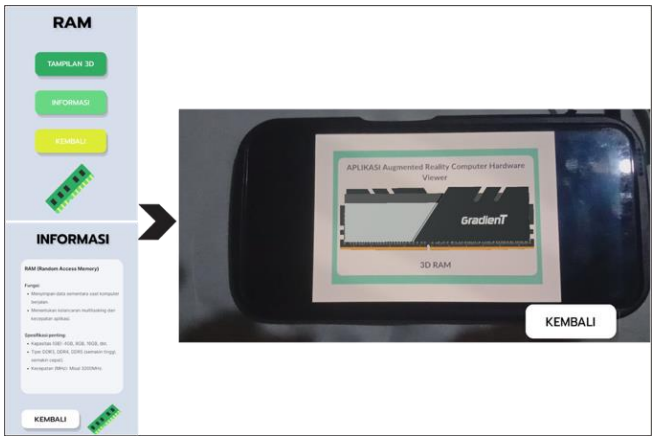

Figure 7. 3D RAM Display

software engineering students with an immersive and interactive learning experience, enabling them to visually explore and understand the various computer hardware components and their relationships within the system.

Figure 6 depicts the user interface of the ArchView Augmented Reality (AR) Computer Hardware Viewer application, specifically focusing on the "MOTHERBOARD" component. The interface displays a 3D model of a motherboard, which can be viewed and interacted with by the user in an augmented reality environment. The "INFORMASI" (Information) section provides additional details about the motherboard hardware, allowing software engineering students to explore and learn about the various components and their functions within the computer system.

Figure 7 showcases the user interface of the ArchView Augmented Reality (AR) Computer Hardware Viewer application, focusing on the "RAM (Random Access Memory)" component. The interface displays a 3D model of a RAM module, which can be viewed and interacted with by the user in an augmented reality environment. The "INFORMASI" (Information) section provides additional details about the RAM hardware, allowing software engineering students to explore and learn about the various specifications and functionalities of this key computer component.

Figure 8 showcases the user interface of the ArchView Augmented Reality (AR) Computer Hardware Viewer application, focusing on the "POWER SUPPLY" component. The interface displays a 3D model of a power supply unit, which can be viewed and interacted with by the user in an augmented reality environment. The "INFORMASI" (Information) section provides additional details about the power supply hardware, allowing software engineering students to explore and learn about the various specifications and functionalities of this crucial computer component.

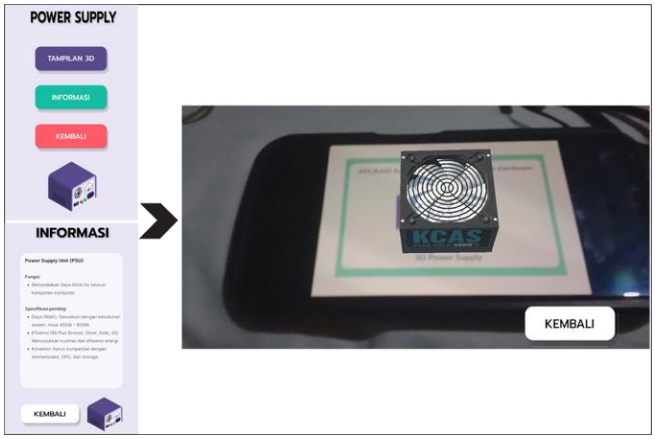

Figure 8. 3D Display of Power Supply

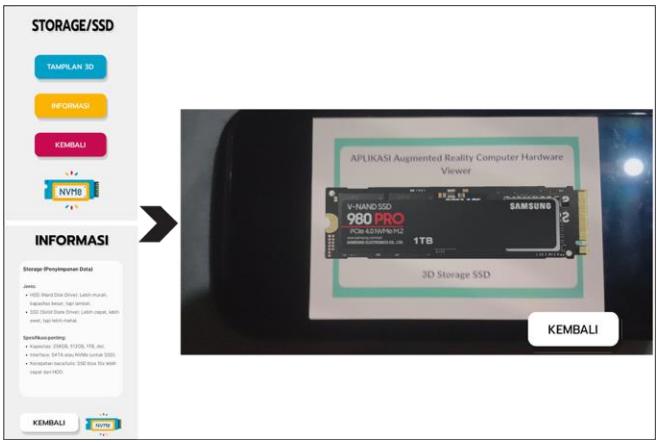

Figure 10. 3D View of the Storage/SSD

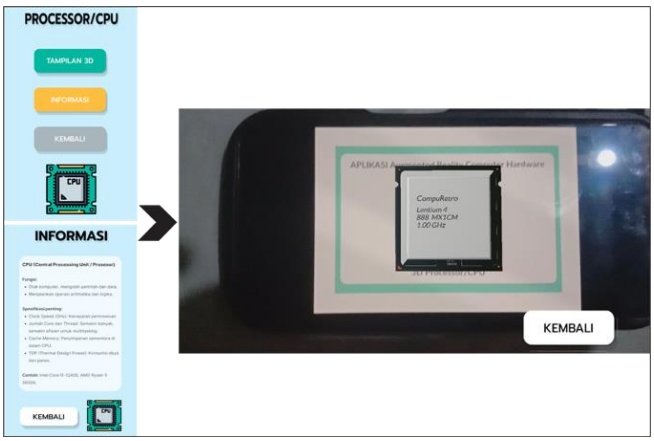

Figure 9. 3D View of the Processor/CPU

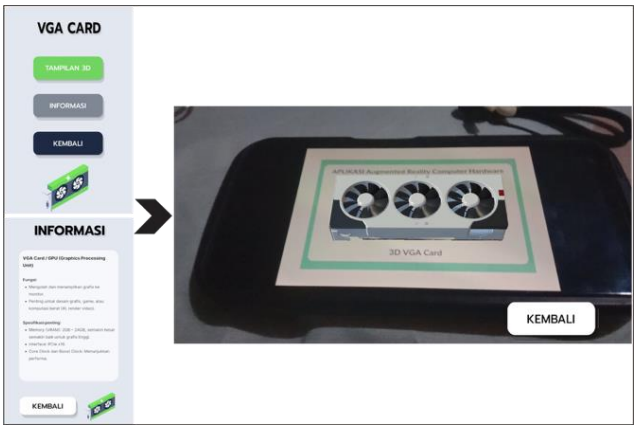

Figure 11. 3D View of the VGA Card

Figure 9 showcases the user interface of the ArchView Augmented Reality (AR) Computer Hardware Viewer application, focusing on the "PROCESSOR/CPU" component. The interface displays a 3D model of a central processing unit (CPU), which can be viewed and interacted with by the user in an augmented reality environment. The "INFORMASI" (Information) section provides additional details about the CPU hardware, allowing software engineering students to explore and learn about the various specifications and functionalities of this crucial computer component.

Figure 10 showcases the user interface of the ArchView Augmented Reality (AR) Computer Hardware Viewer application, focusing on the "STORAGE/SSD" component. The interface displays a 3D model of a Samsung 980 PRO solid-state drive (SSD), which can be viewed and interacted with by the user in an augmented reality environment. The "INFORMASI" (Information) section provides additional details about the SSD hardware, allowing software engineering students to explore and learn about the various specifications and functionalities of this crucial computer storage component.

Figure 11 showcases the user interface of the ArchView Augmented Reality (AR) Computer Hardware Viewer application, focusing on the "VGA CARD" component. The interface displays a 3D model of a high-performance graphics processing unit (GPU), which can be viewed and interacted with by the user in an augmented reality environment. The "INFORMASI" (Information) section provides additional details about the VGA card hardware, such as its function in processing and displaying graphics, as well as key specifications like memory capacity and clock speeds.

This blackbox testing covers the key functionality and user interactions of the ArchView Augmented Reality application, ensuring that the core features and navigation work as expected. The test cases validate the main menu options, component selection, 3D model interaction, and overall usability of the application, representation in Table 1.

This research yielded significant findings that underscore the potential of augmented reality (AR) in enhancing the learning experience in technical fields. The application was developed to provide an interactive platform where students can visualize and interact with 3D models of computer hardware components. During the testing phase, 100 students participated in usability assessments, revealing that 90% of the respondents found the application engaging and beneficial for

understanding complex hardware concepts[27].

Table 1. Black Box Testing Results

Test Case	Input	Expected Output	Actual Output	Pass / Fail
Main Menu Navigation	Select "Mulai" (Start)	Launch the ArchView	ArchView launched successfully	Pass
	Select "Tentang" (About)	Display information about the application	Application information displayed correctly	Pass
	Select "Panduan" (Guide)	Display user guide and instruction	User guide displayed as expected	Pass
	Select "Keluar" (Exit)	Close the application	Application closed successfully	Pass
Componet Selection	Select a component from the "Pilih Komponen" (Select Component) menu	Display 3D model and information of the selected component	3D model and information displayed correctly	Pass
Interaction with 3D models	Tap/click and drag the 3D model	Allow the user to rotate, zoom, and pan the 3D model	3D model interaction worked as expected	Pass
Back Navigation	Select "Kembali" (Back) from the component details screen	Return to the main menu	Returned to the main menu successfully	Pass
Overall Functionality	Navigate through all the menu options and interact with the 3D models	Smooth and intuitive user experience without any errors or crashes	User experience was smooth and intuitive, no issues encountered	Pass

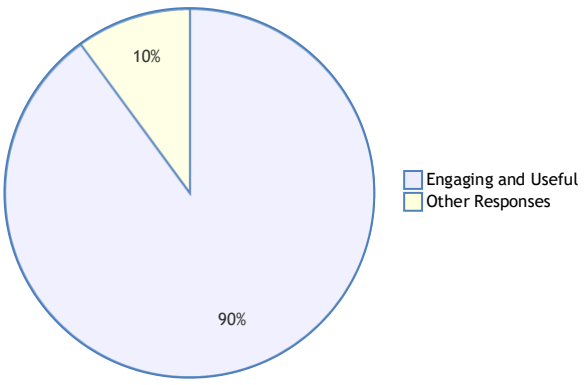

Figure 12. Archview AR Usability Assessment

Figure 12 demonstrates that the vast majority of the participants, 90 out of the 100 students, positively evaluated the ArchView AR application, indicating its effectiveness in enhancing the software engineering learning experience through the integration of augmented reality technology.
The key findings are:

- 90% of the respondents found the ArchView AR application to be engaging and useful for understanding complex hardware concepts.
- The remaining 10% of respondents had other responses, such as finding the application not engaging or not useful for their learning needs.

IV. CONCLUSION

In conclusion, the design and development of the ArchView Augmented Reality Computer Hardware Viewer application represent a significant advancement in enhancing the learning experience in software engineering education. By integrating 3D modeling and augmented reality technology, the application provides an interactive and immersive platform for students to explore computer hardware components in a detailed manner. The research demonstrated that students showed a high level of engagement and understanding when using the application, highlighting the effectiveness of augmented reality as a pedagogical tool. Despite facing challenges such as resource limitations and the need for curriculum adjustments, the positive feedback from users indicates that ArchView has the potential to revolutionize how technical subjects are taught. Overall, this study contributes to the ongoing exploration of innovative educational technologies and underscores the importance of adapting to new teaching methodologies in the digital age.

Future research could explore ways to further enhance the ArchView AR application's learning capabilities, such as incorporating interactive tutorials, quizzes, or gamification elements to reinforce key hardware concepts. Researchers may also investigate integrating the application with online learning platforms or developing a mobile version to improve accessibility and enable seamless learning experiences across devices. Additionally, studies could evaluate the application's effectiveness in improving students' understanding and retention of computer hardware fundamentals, as well as its impact on their overall software engineering skill development. Exploring the potential for the ArchView application to be adapted for different educational levels or specialized hardware domains could also yield valuable insights for expanding its reach and impact within software engineering curricula.

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REFERENCES

[1] V. V Babkin, V. V Sharavara, V. V Sharavara, V. V Bilous, and ..., *Using augmented reality in university education for future IT specialists: educational process and student research work*. ds.knu.edu.ua, 2021. [Online]. Available: http://ds.knu.edu.ua/jspui/handle/123456789/3771

[2] Z. B. Akhtar and A. T. Rawol, "Artificial intelligence (AI) and extended reality (XR): a biomedical engineering perspective investigation analysis," *... of Electronics, Electromedical Engineering ...*, 2024, [Online]. Available: http://ijeeemi.org/index.php/ijeeemi/article/view/5

[3] L. C. Bazavan, H. Roibu, F. B. Petcu, and ..., "Virtual reality and augmented reality in education," *... Engineering ...*, 2021, [Online]. Available: https://ieeexplore.ieee.org/abstract/document/9531005/

[4] O. I. R. Farisi and G. Q. O. Pratamasunu, "Mobile Augmented Reality sebagai media pembelajaran interaktif jaring-jaring kubus dan balok," *NJCA (Nusantara Journal of Computers and Its Applications)*, vol. 3, no. 2, pp. 96–104, 2018.

[5] A. V Grinshkun, M. S. Perevozchikova, E. V Razova, and ..., "Using Methods and Means of the Augmented Reality Technology When Training Future Teachers of the Digital School.," *European Journal of ...*, 2021, [Online]. Available: https://eric.ed.gov/?id=EJ1312049

[6] S. Gottschalk, E. Yigitbas, E. Schmidt, and ..., "Model-based product configuration in augmented reality applications," *... software engineering*, 2020, doi: 10.1007/978-3-030-64266-2_5.

[7] A. K. Jumani, W. A. Siddique, A. A. Laghari, and ..., "Virtual reality and augmented reality for education," *Multimedia computing ...*, 2022, doi: 10.1201/9781003196686-9.

[8] P. P. Nechypurenko, V. G. Stoliarenko, T. V Starova, and ..., *Development and implementation of educational resources in chemistry with elements of augmented reality*. elibrary.kdpu.edu.ua, 2020. [Online]. Available: https://elibrary.kdpu.edu.ua/handle/123456789/3751

[9] R. Kaviyaraj and M. Uma, "A survey on future of augmented reality with AI in education," *2021 International Conference on ...*, 2021, [Online]. Available: https://ieeexplore.ieee.org/abstract/document/9395838/

[10] P. S. Piemonte, D. D. R. Rosario, J. D. Gosnell, and ..., "Augmented reality display," *US Patent ...*, 2021, [Online]. Available: https://patents.google.com/patent/US10922886B2/en

[11] N. I. M. Enzai, N. Ahmad, M. A. H. A. Ghani, and ..., "Development of augmented reality (AR) for innovative teaching and learning in engineering education," *Asian Journal of ...*, 2020, [Online]. Available: https://ir.uitm.edu.my/id/eprint/115439/

[12] M. I. Rosadi and I. Maulidi, "PENERAPAN METODE MDLC PADA RANCANG BANGUN APLIKASI PEMBELAJARAN BIOLOGI TINGKAT SLTP MATERI RANGKA DAN OTOT MENGGUNAKAN AUGMENTED REALITY," *NJCA (Nusantara Journal of Computers and Its Applications)*, vol. 7, no. 1, pp. 39–48, 2022.

[13] M. Muttaqin *et al.*, *Konsep Dasar Kecerdasan Buatan*. Yayasan Kita Menulis, 2023.

[14] A. Kompaniets, H. Chemerys, and I. Krasheninnik, *Using 3D modelling in design training simulator with augmented reality*. ds.knu.edu.ua, 2020. [Online]. Available: http://ds.knu.edu.ua/jspui/handle/123456789/2160

[15] S. Wahyuddin *et al.*, *Penerapan Artificial Intelligence dalam TI*. Yayasan Kita Menulis, 2025.

[16] A. Álvarez-Marín and ..., "Augmented reality and engineering education: A systematic review," *IEEE transactions on ...*, 2022, [Online]. Available: https://ieeexplore.ieee.org/abstract/document/9690001/

[17] A. Tholib, "RANCANG BANGUN APLIKASI AUGMENTED REALITY KAIFATUS SHOLLI BERBASIS ANDROID," *NJCA (Nusantara Journal of Computers and Its Applications)*, vol. 7, no. 2, pp. 49–58, 2022.

[18] R. F. Ramadhan *et al.*, *Kecerdasan Buatan Digital*. Global Eksekutif Teknologi, 2023.

[19] A. A. Permana *et al.*, *Machine Learning*. Global Eksekutif Teknologi, 2023.

[20] W. Andriyani, R. Sacipto, D. Susanto, C. Vidiati, R. Kurniawan, and R. A. G. Nugrahani, *Technology, Law And Society*. Tohar Media, 2023.

[21] A. Impron *et al.*, *INTEGRASI TEKNOLOGI INFORMASI DALAM DESAIN PEMBELAJARAN MODERN*. Penerbit Widina, 2025.

[22] K. Samosir, S. Wahyuddin, and ..., *Sistem Basis Data*. books.google.com, 2022.
[23] S. Wahyuddin *et al.*, "Teknologi Informasi," 2025.
[24] L. W. Santoso *et al.*, "Logika Informatika," 2023, *Global Eksekutif Teknologi*.
[25] S. H. Wibowo *et al.*, "Digital technology in the modern era," *Pt global technology executive*, 2023.
[26] R. Nuraini *et al.*, *Organisasi Dan Arsitektur Komputer*. Global Eksekutif Teknologi, 2023.
[27] S. Wahyuddin, N. Heryana, A. S. Atichasari, N. Simarmata, A. Triwijayati, and A. Asroni, *Metode Riset Kualitatif*. Get Press Indonesia, 2023.