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DEVELOPMENT OF AUGMENTED REALITY CAMPUS NAVIGATION APPLICATION USING RAPID APPLICATION DEVELOPMENT APPROACH: A CASE STUDY OF AR HUB @ PUO (JTMK)

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ABSTRACT

Many new students at the Department of Information Technology and Communication (JTMK), Polytechnic Ungku Omar experience challenges in locating campus facilities which can lead to delays and reduced punctuality. This study addresses the problem through the development of AR HUB @ PUO (JTMK), a mobile Augmented Reality (AR) navigation application created as a student Final Year Project (FYP) using the Rapid Application Development (RAD) methodology. The study evaluates the effectiveness of RAD in the design, testing, and deployment of educational AR applications within a limited academic timeframe. The development process comprised four phases, namely Analysis and Quick Design, Prototype Cycles, Testing, and Deployment. Through iterative prototyping and continuous user feedback, the project successfully delivered a functional AR navigation solution within seven weeks. The resulting application provides real time AR navigation overlays, schedule viewing, secure login, and data management. Findings indicate that RAD is an effective framework for small-scale, student-led AR projects in educational contexts. Future work will explore broader device compatibility, offline functionality, and expansion to other departments within the institution.

1. Introduction

Augmented Reality (AR) is quickly becoming a powerful tool education, creating interactive and engaging learning experiences. It helps boost student interest, improves spatial understanding, and connects physical and digital content (Chang et al., 2022). One useful application of AR in education is campus navigation, where students use AR on their phones to find places like lecture halls, labs, and staff offices. These systems make it easier for new students and visitors to find their way, especially when traditional maps and signs are confusing (Nordin et al., 2021).

As technical and vocational institutions grow, their buildings become more complex with many floors and departments. This complexity is evident at the Department of Information Technology and Communication (JTMK), Polytechnic Ungku Omar (PUO) which houses one lecture hall, seven laboratories, and eight lecturer rooms distributed across several levels. Based on observations and preliminary surveys conducted among new students at JTMK, many new JTMK students reported having trouble finding classrooms and staff offices during their first few weeks on campus. These challenges frequently result in delayed class attendance, missed appointments, and added stress, particularly for first-year students. Abdul Rahman et al. (2021) found that about 68% of first-semester students in technical institutions have trouble finding their way around, which can affect their academic performance and punctuality.

AR navigation systems have been proposed as a promising intervention to address these challenges, offering real-time visual cues and interactive overlays that support intuitive movement within large academic spaces. However, the success of AR-based solutions in education does not solely depend on the technology itself. It is also shaped by the development methodology adopted during implementation. Traditional software models like Waterfall or V-Model offer clear steps but are not flexible enough for technologies that need constant user input and regular updates. In contrast, Rapid Application Development (RAD) offers a more dynamic and user-centric approach. It emphasizes fast prototyping, continuous user involvement, and iterative design, which aligns well with the demands of AR application development (Bahari & Pramudwiatmoko, 2025; Maulany et al., 2021).

The development of AR campus navigation systems presents a key trade-off between rapid deployment and comprehensive functionality. Structured development models may offer long-term maintainability, but often delay delivery. On the other hand, RAD's iterative and lightweight framework allows for faster adaptation to evolving requirements, making it particularly suitable for student-led projects within limited academic timeframes. Prior research has shown that RAD is highly effective in small-scale mobile application projects where end user feedback is essential to improve usability and performance (Applied Sciences, 2023; Castillo López et al., 2023).

This study investigates the design and development of AR HUB @ PUO, a mobile AR campus navigation application built as part of a Final Year Project (FYP) by students enrolled in the Diploma in Information Technology (Digital Technology) program at PUO. The development process adopted the RAD methodology and was completed within a seven-week academic semester, as stated in the Final Year Project Guideline (2022). This study evaluates the implementation of the four RAD phases: Analysis and Quick Design, Prototype Cycles, Testing, and Deployment. It also assesses the effectiveness of RAD as a development framework for educational AR applications, particularly within academic environments with limited time and resources.

This case study aims to show how iterative design cycles, student collaboration, and real-time user feedback can contribute to the rapid and effective deployment of AR-based navigation systems tailored to institutional needs. The findings may serve as a model for future AR projects within technical education, particularly those developed under similar time, resource, and institutional constraints.

2. Materials and Methods

This study employed a qualitative case study approach to investigate the application of the RAD methodology in the development of AR HUB @ PUO (JTMK), an AR campus navigation mobile application designed by final-year students from the JTMK at PUO. RAD focuses on speed, iterative prototyping, and user involvement, making it well-suited for short-term mobile app projects where continuous feedback helps improve the final product (Bahari & Pramudwiatmoko, 2025).

The project was conducted during Short Semester 2023 and completed within a tight timeframe of seven weeks. The RAD process adopted consisted of four sequential phases: (1) Analysis and Quick Design, (2) Prototype Cycles, (3) Testing, and (4) Deployment. These phases were iteratively refined based on user input. Figure 1 illustrates the RAD process model used, while Figure 2 outlines the corresponding Gantt chart for project implementation.

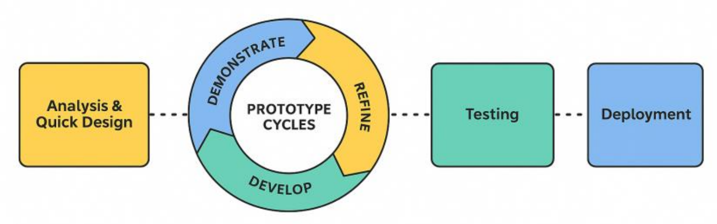

Figure 1: Rapid Application Development (RAD) Methodology

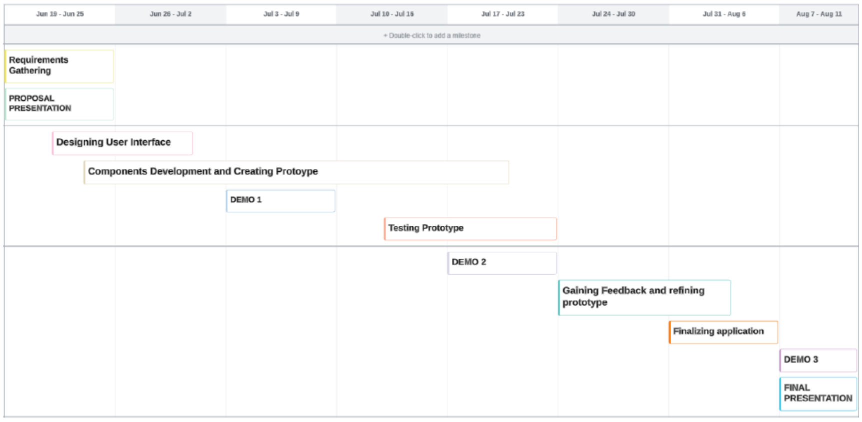

Figure 2: Gantt Chart for the AR HUB @ PUO (JTMK)

2.1 Phase 1: Analysis & Quick Design

The initial phase involved conducting informal interviews with students and lecturers to identify common navigation difficulties within the JTMK building. Observational data showed that students frequently encountered delays in attending lectures due to difficulty locating labs, lecture halls, and staff rooms. Based on these insights, the development team listed what users needed and identified the main usability problems. They also defined the functional and non-functional specifications, including the system scope, security parameters, and technical details. Early interface mockups were created using Unity and Blender**,** leading to the development of a basic conceptual prototype demonstrating user registration and AR navigation components.

2.2 Phase 2: Prototype Cycles

During the prototyping phase, development progressed using Unity Game Engine with Android Software Development Kit, Unity 2021.3 (Android SDK)**,** AR Core 1.32 by AR Foundation**,** and Firebase Authentication v9.0**.** Five student testers gave feedback during development, which helped improve the user interface. Real-time AR overlays and markerless tracking were implemented for Android 7.0+ devices. Lab and staff schedule data were dynamically integrated. A backend admin portal, managed through phpMyAdmin, allowed real-time updates. Additional security features such as account hashing and HyperText Transfer Protocol Secure (HTTPS) encryption were also incorporated. The Android SDK was used to compile and test the application to ensure full compatibility across Android devices.

2.3 Phase 3: Testing

System testing was conducted across multiple Android devices to ensure compatibility. Unit testing verified the reliability of core features such as user login, lab schedule display, and AR navigation overlays. Table 1 shows all of those that achieved a 100% pass rate. Integration testing confirmed that features like registration, login, navigation, and admin updates worked smoothly together. Functional testing confirmed the application's responsiveness and AR tracking accuracy. Performance testing showed latency consistently below 500 milliseconds (ms)**.** Usability testing required users to locate specific rooms under real conditions, confirming the practical functionality of the application. Nonetheless, high battery consumption and occasional tracking delays on low-end devices were observed.

2.4 Phase 4: Deployment

After successful testing, the application was shared within JTMK using APK sideloading. Admins updated room schedules in real time through the backend. This RAD approach gives other institutions a simple model to build AR navigation apps quickly, even with limited resources.

3. Results

The development and testing phases of AR HUB @ PUO (JTMK) demonstrate that the RAD methodology facilitated a rapid and successful deployment of a functional AR navigation application within a seven-week academic timeline. The iterative nature of RAD enabled early detection and resolution of usability challenges, resulting in improvements in interface layout, AR marker accuracy, and schedule accessibility. Feedback from student testers indicated high satisfaction with the app's intuitive design and ease of locating key destinations.

3.1 Product Development Outcome

This application completed all four phases of RAD within the allocated seven-week timeframe. The final build incorporated real-time AR navigation, lab and staff room schedule access, Firebase-backed user authentication, and a secure backend. All functional and non-functional

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requirements were achieved as stated in the FYP Technical Report (2023). Figure 3 illustrates the application's user interface components, including the login page, side panel navigation, and AR views.

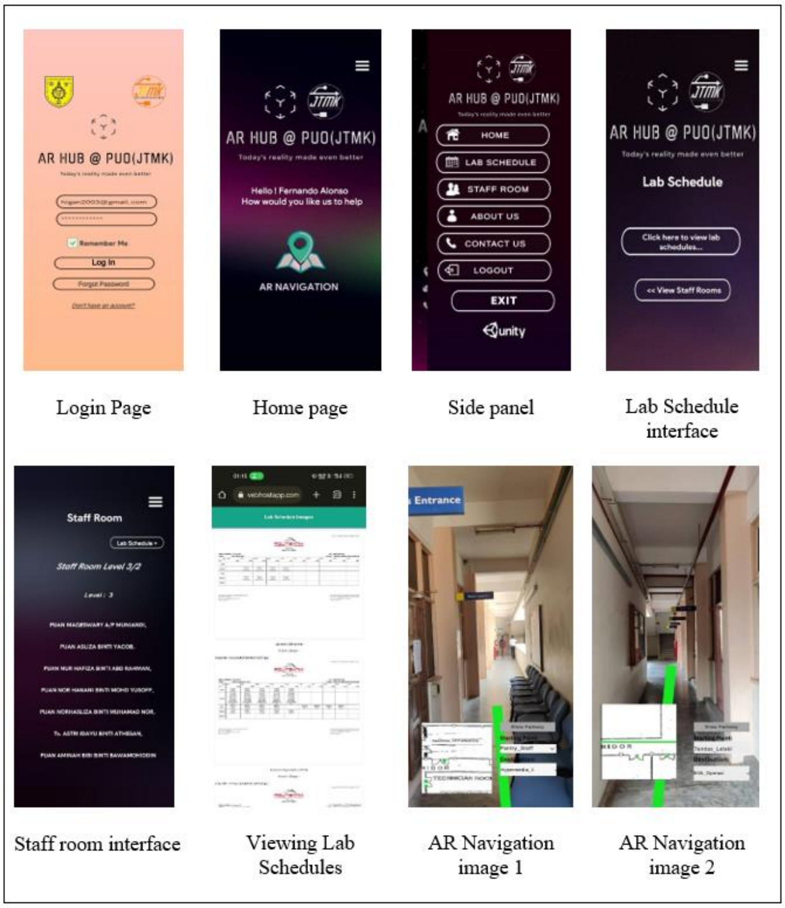

Figure 3: AR HUB @ PUO (JTMK) User Interface

3.2 Usability Testing Results

Five student participants with Android devices of varying specifications tested the application. Tasks included locating labs and checking class schedules. Over 90% completed tasks on their first attempt, confirming strong system usability. Participants described the interface as intuitive and required minimal instruction to operate. The AR detection performed reliably in well-lit conditions, enhancing navigation clarity.

3.3 Unit and Integration Testing

Unit tests verified core components such as login, AR path rendering, lab schedule viewing, and staff room details. All features passed validation with a 100% success rate as listed in Table 1. The integration testing in Table 2 confirmed uninterrupted user flow between registration, login, navigation, and content updates. System latency consistently remained below 500 ms, ensuring smooth real-time interactions.

Table 1: Unit Testing

No.	Test Case Name	Test Procedure	Expected Result	Tester	Result
1	Login	The user fills in their email and password in the respective input fields to log in to the application.	The user’s login credentials will be stored in the database.	Zamir	Pass
2	Augmented Reality Navigation	The user selects the starting point and the destination they want to arrive at.	The user will be directed by a highlighted AR pathway to reach their destination.	Magendran	Pass
3	Displaying staff room details	The user should click the ‘Staff Room’ button in the side panel.	The user can view all staff room names with the respective levels and the staff name.	Theyshigan	Pass
4	Displaying the lab schedule	The user should click the ‘Lab Schedule’ button in the side panel.	The user will be redirected to a website containing every lab schedule for the respective labs according to the semester.	Theyshigan	Pass
5	Updating the staff room and lab schedule details	The administrator should input the information that needs to be changed by clicking the ‘Edit’ button and inputting the new data.	Users can view the changes in the information.	Zamir	Pass

Table 2: Integration Testing

No.	Test Case Name	Test Procedure	Expected Result	Tester	Result
1	Registration	The user fills in name, email, password, and confirmation password.	The user will be redirected to the login page.	Theyshigan	Pass
2	Login	The user is required to input their email and password.	The user is redirected to the home page.	Theyshigan	Pass
3	Switching interfaces	The user should click the available options in the side menu by clicking the hamburger icon.	The user is instantly able to switch between multiple interfaces.	Zamir	Pass
4	Camera accessibility	The user should allow permission to access the camera of the user's mobile device for this application.	The user could view the surrounding area of the scene from their phone through their device's camera.	Magendran	Pass
5	Display of AR pathway	The user should click the 'show pathway icon' to display the highlighted AR route.	The user can navigate easily using the highlighted pathway that guides them from their starting point to the intended destination.	Magendran	Pass
6	Updating the staff room and lab schedule contents	The administrator should input the information that needs to be changed by clicking the 'Edit' button and inputting the new data.	The users in the application will be able to view the changes in the information once the application has been updated.	Zamir	Pass

3.4 Deployment and User Feedback

The application was deployed internally via APK, limited to the PUO campus community. User feedback, especially from new students, highlighted its usefulness for campus navigation. The admin portal enables real-time updates, which were appreciated by the department and staff. As shown in Table 3, key benefits include AR-based navigation, personalized routes, a user-friendly interface, and real-time information updates. However, limitations such as limited device compatibility, high battery usage, and the need for stable internet were noted in Table 4. Users also suggested adding offline features and expanding the app to other departments.

Table 3: Advantages of AR HUB @ PUO (JTMK)

Advantages	Description
Enhanced navigation experience	AR HUB @ PUO (JTMK) gives users an interactive AR experience by guiding them with a highlighted path to help them find their way around the JTMK building.
Customized pathways	Users receive personalized routes based on their destination, making it easier to navigate complex buildings like JTMK and saving time with the most efficient paths.
User-friendly interface	Users can easily understand how the app works and navigate it using the interactive side menu, which lets them switch between features and log out smoothly.
Real-time information updates	Users receive the latest JTMK information from authorized admins through the admin site.

Table 4: Disadvantages of AR HUB @ PUO (JTMK)

Disadvantages	Description
Limited Device Compatibility	AR HUB @ PUO (JTMK) is built using AR Core, which only works on Android devices with version 7.0 or higher. This limits access for users with older Android phones or iOS devices.
High battery consumption	This application relies heavily on the camera and AR features, which can quickly drain the device's battery, leading to shorter usage time during extended sessions.
Requires a constant internet connection	This application needs a stable internet connection for smooth AR navigation and real-time updates. In areas with weak connectivity, users may face problems that affect their experience.

4. Discussion

The high usability success rate supports the argument that AR is a viable tool for improving spatial orientation in educational settings. This complements prior research by Abdul Rahman et al. (2021), which identified wayfinding as a major challenge for technical students. The intuitive interface and ease of adoption reported by users reinforce the potential of AR as a solution for first-time campus navigation.

Performance limitations observed during testing, particularly on lower-specification devices, align with broader challenges in mobile AR deployment discussed by Chang et al. (2022). These include energy consumption, device compatibility, and environmental dependencies.

These constraints suggest that while the technology is promising, further optimization is needed for broad adoption.

The success of internal deployment and the positive reception of the admin content portal further demonstrate this project’s potential for wider institutional use. However, scalability would require enhancements such as integration with campus-wide systems, database expansion, and consideration for offline capabilities to support diverse usage scenarios.

Future research could focus on enhancing AR precision with technologies such as Indoor Positioning Systems (IPS) and cloud anchors. Expanding the system’s coverage to include other departments or campuses would also allow for comparative analysis of user behavior across academic environments. Additionally, studying the long-term impact of AR navigation on student punctuality and engagement could offer further insight into its educational value.

In summary, the development of AR HUB @ PUO (JTMK) validates the application of RAD in educational AR projects. The methodology’s focus on iterative feedback, rapid delivery, and targeted scope effectively addressed real-world navigation challenges within a constrained resource environment.

5. Conclusion

This study found that the RAD methodology was highly effective for developing AR HUB @ PUO (JTMK), a mobile AR application designed to help new students navigate campus. Within seven weeks, the project produced a fully functional system with real-time overlays, schedule viewing, secure login, and data management. The results show that RAD is a good fit for small to medium academic projects that need flexibility, quick updates, and user feedback (Bahari & Pramudwiatmoko, 2025; Maulany et al., 2021). Usability testing showed that over 90% of first-time users used the application successfully, proving AR can help reduce navigation stress and improve direction finding in education (Chang et al., 2022; Nordin et al., 2021). RAD’s iterative process also helped enhance the interface and AR markers, aligning with User-Centered Design approach highlighted by Castillo Lopez et al. (2023).

Although the project was successful, it also showed some limitations especially with device compatibility and battery use, similar to issues found in past studies on AR in education (Rodriguez & Smith, 2022). These issues point to the need for future improvements like offline features, support for more devices, and better energy use. In practice, AR HUB @ PUO (JTMK) helped students find their way around and gave staff useful tools through its real-time admin portal. This supports earlier research calling for mobile solutions tailored to technical education (Abdul Rahman et al., 2021) and shows that RAD is a smart method for building apps in resource-limited settings (Applied Sciences, 2023). Overall, this study confirms that RAD is an effective and flexible way to develop mobile AR navigation apps for academic use. It provides a model that other institutions can follow to improve the student experience with fast, user-friendly AR tools.

6. Acknowledgements

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7. References

Abdul Rahman**,** K. A., Abdul Jalil, N. A., Arsad, M. A., & Ismail, M. E. (2021). *Development of Mobile Application Framework Based on Competency-Based Education for Technical and Vocational Education*. Journal of Technical Education and Training, 13(2), 44-52. https://doi.org/10.30880/jtet.2021.13.02.005

Applied Sciences. (2023). *Applications Analyses, Challenges and Development of Augmented Reality in Education, Industry, Marketing, Medicine, and Entertainment*. Applied Sciences, 13(5), 2766. https://doi.org/10.3390/app13052766

Bahari, A. F., & Pramudwiatmoko, A. (2025). *Implementation of Rapid Application Development (RAD) Method for Mobile-based Ice Cream Ordering Application.* MALCOM: Indonesian Journal of Machine Learning and Computer Science, 5(1), 283–291. https://doi.org/10.57152/malcom.v5i1.1747

Castillo López, M. I., Eslava Cervantes, A. L., & de la Cruz Martínez, G. (2023). *Applying user experience and user-centered design software processes in undergraduate mobile application development teaching.* arXiv preprint arXiv:2308.07494. https://arxiv.org/abs/2308.07494

Chang, H.-Y., Binali, T., Liang, J.-C., Chiou, G.-L., Cheng, K.-H., Lee, S. W.-Y., & Tsai, C.-C. (2022). *Ten years of augmented reality in education: A meta-analysis of (quasi-) experimental studies to investigate the impact.* Computers & Education, 191, 104641. https://doi.org/10.1016/j.compedu.2022.104641

Department of Polytechnic Education and Community College. (2022). *DFT50114 Final Year Project Guidelines (Diploma in Information Technology (Digital Technology)) (2022 ed.)*. Politeknik Ungku Omar. https://isbn.gov.my (eISBN 978-967-2421-47-4)

Maulany, R., Hasan, B., Abdullah, A. G., & Rohendi, D. (2021). *Design of learning applications using the Rapid Application Development method.* IOP Conference Series: Materials Science and Engineering, 1098(2), 022090. https://doi.org/10.1088/1757-899X/1098/2/022090

Muhammad Zamir bin Azlan, Theyshigan a/l Mani Balan, & Magendran a/l Rajendran (2023). *AR HUB @ PUO (JTMK)* –Technical Report *(Unpublished Internal Technical Report).* Department of Information Technology and Communication, Politeknik Ungku Omar.

Nordin, N., Markom, M. A., Suhaimi, F. A., & Ishak, S. (2021). *A web-based campus navigation system with mobile augmented reality intervention*. Journal of Physics: Conference Series, 1997(1), 012038. https://doi.org/10.1088/1742-6596/1997/1/012038

Rodriguez, A., & Smith, J. (2022). *Limitations of GPS in AR-based indoor navigation: A review of educational institutions.* International Journal of Emerging Technologies in Learning (iJET), 17(5), 112–120. https://doi.org/10.3991/ijet.v17i05.28732