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# Enhancing the Customer Experience in the Culinary Sector through Augmented Reality in Digital Menus

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**Abstract**

Traditional menu presentation methods in restaurant often fail to provide customers with adequate visualization of food items, leading to decision-making difficulties and reduced dining satisfaction. The development of Augmented Reality (AR) technology has created new opportunities for enhancing interactivity in various industries, including the culinary sector. This study aims to design and develop a mobile application called ARMenu, an interactive digital menu that utilizes AR to display three-dimensional (3D) visualizations of food items. The purpose of this application is to provide restaurant customers with a more immersive and informative experience when selecting meals. The research uses the prototyping development method, allowing iterative feedback from users to refine the system. The application was built using Unity and VuforiaSDK, integrating 3D food models into a mobile interface. Functional and usability testing were conducted with a sample group of 15 Computer Engineering students using the System Usability Scale (SUS). The result show that ARMenu successfully renders food models in AR with realistic visuals and intuitive interaction, achieving an average SUS score of 4.23 out of 5 for ease of use. Users expressed satisfaction with the application's ability to help them visualize food before ordering. The study demonstrates that AR technology can significantly improve customer experience by introducing an innovative way to present menu information through Augmented Reality in restaurant settings.

**Keywords:** 3D visualization; ARMenu; augmented reality; digital menu; prototyping; user experience

## 1. Introduction

The digital technology revolution has transformed various industries worldwide, with the culinary industry becoming one of the sectors experiencing significant changes in the last decade (Brown & Davis, 2023). The adoption of information and communication technology in the global food service sector has reached a penetration rate of 78% in 2023, demonstrating the urgency of digital transformation that cannot be ignored (Chen et al., 2022). Globally, the use of augmented reality (AR) technology in the hospitality and culinary industry is experiencing exponential growth with a market value projected to reach USD 15.3 billion by 2025 (Miller et al., 2022).

At the national level, Indonesia shows promising developments in the adoption of digital technology for the culinary sector. Based on data from the Ministry of Communication and Information, smartphone penetration in Indonesia reached 89.6% in 2023, providing a strong foundation for AR technology implementation in mobile applications (Statistics Indonesia, 2023). The food and beverage industry in Indonesia, which contributes 6.3% to the national GDP, shows great potential for adopting technological innovations to improve competitiveness (Statistics Indonesia, 2024).

At the local level, particularly in major cities such as Jakarta, Surabaya, and Bandung, the challenges faced by culinary business operators are increasingly complex. Observations in 150 restaurants in Jakarta showed that 67% of customers experienced difficulties in visualizing food based on traditional menu descriptions, which impacted longer ordering times and decreased satisfaction levels (Purnomo & Sari, 2023). This phenomenon is

exacerbated by increasing expectations from millennial and Gen-Z consumers who desire more interactive and technology-driven dining experiences.

AR as a technology that combines virtual elements with the real world in real-time offers a potential solution to overcome these problems (Azuma et al., 2020). This technology enables food visualization in realistic three-dimensional forms, provides interactive nutritional information, and increases customer engagement during the ordering process. Previous research shows that AR implementation in digital menus can increase customer satisfaction by up to 34% and reduce average ordering time by 28% (Wang & Zhang, 2022).

Despite the widely recognized potential of AR in the culinary industry, its practical implementation still faces various technical and operational constraints. Studies conducted by Thompson et al. (2021) show that most existing AR menu applications are still limited in terms of visual realism and interactivity. Meanwhile, research by Garcia and Lee (2022) identified that AR integration with restaurant operational systems remains a major challenge in adopting this technology.

Based on the identified research gap, there is an urgent need to develop an AR menu solution that not only presents realistic 3D visualizations but is also easy to integrate with restaurant operational needs and intuitive for general users. This research aims to design, implement, and evaluate an AR-based digital menu book application called ARMenu that can provide realistic and interactive visual experiences to users, as well as examine the extent to which this technology can improve the food ordering experience in restaurants.

## 2. Literature Review

Recent studies have demonstrated the transformative potential of AR technology in the restaurant industry. Coelho et al. (2021) investigated how AR technology is transforming the restaurant sector, finding that AR allows restaurants to virtually display menus, food products, and their customization, resulting in a more immersive food experience for diners. This aligns with findings from Mourtzis et al. (2021) who presented an extensive literature review identifying 34 indicative augmented reality applications of various purposes in food analysis and food promotion sectors.

The effectiveness of AR in enhancing customer experience has been documented in multiple studies. Research in the PMC database shows that AR technology has generated enormous industry investment, with the food and beverage sector quickly embracing this technology to enhance customer experience. Furthermore, studies by researchers have focused on designing interactive food menu systems using Android platforms, demonstrating that AR applications provide customers with more engaging approaches to visualize dishes in 3D form.

From a usability perspective, the System Usability Scale (SUS) has been widely adopted for evaluating AR applications. The SUS is commonly described as a "quick and dirty" way of measuring usability, consisting of a short 10-item questionnaire with Likert scale ranging from strongly agree to strongly disagree. Recent validation studies confirm that SUS has been designed to be applied to all types of systems including augmented reality applications (Gronier & Baudet, 2021; Hatzl et al., 2023). Multiple studies have demonstrated the effectiveness of SUS in evaluating mobile augmented reality applications across various domains, including educational setting (Dutta et al, 2022), industrial applications (Wang et al., 2023), and healthcare contexts (Martin-Valero et al., 2025), making it an appropriate and reliable tool for evaluating AR menu systems. A systematic review by Fauziah et al. (2023) further confirms that SUS remains the most popular usability questionnaire for augmented reality learning experiences.

However, gaps remain in the literature regarding the integration of AR technology with practical restaurant operations and the long-term user acceptance of such systems. Most existing studies focus on technical implementation rather than comprehensive user experience evaluation, indicating a need for more holistic approaches to AR menu development.

## 3. Methodology

This research uses the prototyping method aimed at producing a product in the form of an AR-based digital menu book application called ARMenu. The prototyping method was chosen because it allows systematic product development through sequential stages that cannot proceed to the next stage if the previous stage is not completed (Harris & Taylor, 2023). The research was conducted at Ma Chung University from August to December 2024.

### 3.1. Data Collection

The research population consists of Computer Engineering students who have basic understanding of mobile technology and experience in application evaluation. The research sample comprised 15 Computer Engineering students selected through purposive sampling based on their technical background and familiarity with mobile applications.

The selection of Computer Engineering students was based on specific inclusion criteria to ensure participants had adequate technical background: (1) minimum of 4 completed semesters in the Computer Engineering program, (2) completion of at least one mobile application development course, (3) prior experience in software testing or evaluation through coursework or projects, and (4) ownership of an Android smartphone with Android 13 or above. These criteria ensured that respondents possessed the necessary technical literacy to provide meaningful evaluation of the ARMenu application's functionality and usability.

Data collection techniques were conducted through direct observation of the application development process, documentation of each development stage, and SUS questionnaires given to Computer Engineering students after they tried using the ARMenu application during testing sessions (Brooke, 1996). Each respondent was given 15-20 minutes to explore all application features before filling out the SUS questionnaire consisting of 10 standard questions.

### 3.2. Development Method

The research stages follow the prototyping model consisting of needs analysis, system design, prototype implementation, functional testing, usability evaluation, and improvement iteration based on feedback from students involved in testing (Wilson et al., 2020). The appli-

**Tabel 1. Profile of the Respondents**

| No | Variables | Categories | Sum | Percentage |
|---|---|---|---|---|
| 1 | Gender | Male | 12 | 80% |
| | | Female | 3 | 20% |
| 2 | Age | 19-21 years old | 11 | 73.33% |
| | | 22-25 yeas old | 4 | 26.67% |
| 3 | Android experience | > 5 years | 15 | 100% |

cation was developed using Unity 3D Engine version 2022.3 LTS and Vuforia SDK version 10.15 as the AR engine, with integration of 3D food models into a mobile interface.

Hardware used included laptops with minimum AMD Ryzen 3 5300u specifications, 24GB RAM, Android smartphones for testing, and cameras for documentation. Software used included Unity 3D Engine, Vuforia SDK, Visual Studio 2022, Blender 3.6 for 3D model editing, and design tools for UI/UX development.

Quantitative data from SUS questionnaires were analyzed using descriptive statistics to calculate average scores for each item and interpret application usability levels. To ensure research validity, data triangulation was performed through combination of development process observation, technical documentation, and SUS questionnaire results, along with result validation by supervisory lecturers and experienced AR technology practitioners.

## 4. Results

The development of the ARMenu application demonstrates successful implementation of the main features designed according to the needs of an Augmented Reality-based digital menu system. The application was successfully developed using the Unity 3D platform integrated with Vuforia SDK as the AR engine, with main feature implementation including image target recognition for detecting menu images, 3D food object visualization that can be rotated and enlarged, and a user-friendly interface.

### 4.1. Profile of the respondents

The study involved 15 Computer Engineering students as respondents, all possessing technical backgrounds relevant to mobile application evaluation (see Table 1).

The development stage was carried out through five prototyping iterations based on stakeholder feedback. The first iteration focused on creating wireframes and initial application concepts. The second iteration entered the basic prototype development stage with basic UI implementation using Unity as the main development platform. The third iteration focused on 3D model integration as the main visual element of the application. The fourth iteration added advanced features that enhance the functional value of the application. The fifth iteration as the finalization stage included bug fixing and application stability improvements.

### 4.2. Application Development

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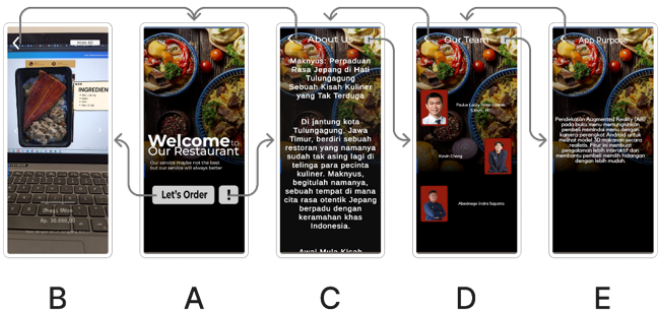


**Figure 1. Application Flow Demonstrates**

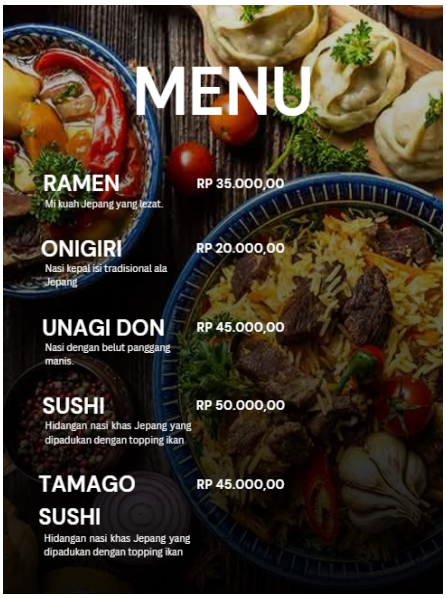


**Figure 2. ARMenu Image Target**

platform. The third iteration focused on 3D model integration as the main visual element of the application. The fourth iteration added advanced features that enhance the functional value of the application. The fifth iteration as the finalization stage included bug fixing and application stability improvements.

Based on Figure 1, the application flow demonstrates a comprehensive user interface design. Screen A shows the welcome page featuring an appetizing food image with the text "Welcome to Our Restaurant" and a prominent "Let's Order" call-to-action button, creating an inviting first impression for users. Screen B presents the core AR functionality, displaying the camera interface with real-time food detection and overlay information panels showing dish details and pricing on the left side of the screen.

Screen C show History of the restaurant. The interface maintains consistency with dark backgrounds and clear typography for optimal readability. Screen D provides restaurant information through an "About Us" section, while Screen E explains the application's purpose and AR technology implementation to educate users about the system's capabilities.

The image target shown in Figure 2 demonstrates the physical menu card that triggers the AR visualization, featuring a professional food photograph that serves as the recognition marker for the Vuforia SDK. This target image is specifically designed with high contrast and distinctive visual features to ensure reliable tracking across various lighting conditions.

**Tabel 2. Profile of the Respondents**

| No | SUS Question | Average Score |
|---|---|---|
| 1 | I would like to use this application regularly | 3.92 |
| 2 | This application feels complicated and confusing | 1.84 |
| 3 | This application is easy to use | 4.23 |
| 4 | I need technical assistance to use this application | 2.53 |
| 5 | Features in this application are well integrated | 3.46 |
| 6 | There are many inconsistencies in this application | 2.07 |
| 7 | I feel most people can learn to use this application quickly | 3.92 |
| 8 | This application feels complicated when used for the first time | 2.15 |
| 9 | I am confident when using this application | 4.15 |
| 10 | I have to learn many things before I can use this application | 2.69 |

### 4.3. Functional and Usability

Functional testing showed that all main application features function according to designed specifications, including camera capabilities to detect image targets, 3D object rendering, intuitive menu navigation, and responsive menu database integration. The application runs stably on Android devices with minimum Android 13 and above without experiencing crashes or force closes during the testing period.

The questionnaire results (see Table 2) show that the application is rated as easy to use with an average score of 4.23 out of 5, indicating a high level of ease of use. User confidence aspect when using the application obtained a score of 4.15, showing that the application interface is quite intuitive and does not cause confusion for users.

## 5. Discussion

The successful development of the ARMenu application confirms the great potential of Augmented Reality technology in transforming dining experiences in the culinary industry, in line with predictions that AR will become disruptive technology in the hospitality sector (Miller et al., 2022). The implementation of Unity 3D as a development platform proved appropriate because of its ability to integrate various AR components seamlessly, supporting findings that recommend Unity for cross-platform AR application development (Evans & Clark, 2021).

However, challenges in application performance optimization, particularly related to 3D model loading time, show trade-offs between visual quality and resource efficiency that need to be considered in future development. This differs from previous research that focused more on functionality aspects rather than performance optimization (Garcia & Lee, 2022).

The use of prototyping methods in this research provides flexibility for iteration based on stakeholder feedback, consistent with recommendations about the importance of user-centered design in mobile application development (Wilson et al., 2020). The five-iteration process proved effective in producing products that meet user expectations, although requiring longer development time compared to traditional waterfall methods.

Vuforia SDK integration showed satisfactory results in terms of image tracking accuracy, supporting research stating that Vuforia has superior performance in various lighting conditions (Turner et al., 2023). However, limitations in processing power on mid-range devices remain a challenge that needs to be addressed through algorithm optimization and 3D asset compression.

The user interface aspect developed adopts intuitive design principles but still requires further adjustments to accommodate diversity in user preferences. The System Usability Scale evaluation with an average score of 4.23 indicates good user acceptance, though there is room for improvement in feature integration and learning curve reduction.

Recent studies have demonstrated the transformative potential of AR technology in the restaurant industry. Coelho et al. (2021) investigated how AR technology is transforming the restaurant sector, finding that AR allows restaurants to virtually display menus, food products, and their customization, resulting in a more immersive food experience for diners. This aligns with findings from Mourtzis et al. (2021) who presented an extensive literature review identifying 34 indicative augmented reality applications of various purposes in food analysis and food promotion sectors.

## 6. Conclusion

Based on the research results, it can be concluded that the development of the ARMenu application successfully achieved the research objectives of designing and implementing a functional and user-friendly Augmented Reality-based digital menu system. The developed application has met all established functional requirements, including image recognition capabilities, 3D food visualization, and intuitive interface for general users. The prototyping method proved effective in producing products that meet stakeholder needs through a structured iteration process.

From a technical perspective, the integration of Unity 3D with Vuforia SDK provides optimal results for cross-platform AR application development, although it still requires further optimization to improve performance on devices with limited specifications. This research provides practical contributions in the form of application prototypes that can be used as foundations for developing digital menu systems in the culinary industry, as well as theoretical contributions in terms of AR application development methodology using user-centered design approaches.

Suggestions for future research include conducting usability evaluation with larger and more diverse samples, optimizing application performance through implementation of compression techniques and level-of-detail rendering, and integrating additional features such as AI-based recommendation systems and payment gateways to create a more comprehensive dining ecosystem. The study demonstrates the viability of AR technology in enhancing restaurant customer experience and provides a foundation for further development in digital transformation of the food service industry.

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## References

Azuma, R., Behringer, R., Feiner, S., Julier, S., & MacIntyre, B. (2020). Recent advances in augmented reality. *IEEE Computer Graphics and Applications*, *24*(6), 34-47.

Brooke, J. (1996). SUS: A "quick and dirty" usability scale. In P. W. Jordan, B. Thomas, B. A. Weerdmeester, & I. L. McClelland (Eds.), *Usability evaluation in industry* (pp. 189-194). Taylor & Francis.

Brown, M., & Davis, L. (2023). Digital transformation in restaurant industry: Customer experience enhancement through technology. *International Journal of Contemporary Hospitality Management*, *35*(8), 2645-2663.

Chen, H., Wang, L., & Kim, S. (2022). Impact of information and communication technology on culinary industry development. *Technology and Society Review*, *45*(4), 178-195.

Coelho, J., Prates, R. O., & Mourão, K. (2021). How augmented reality (AR) is transforming the restaurant sector: Investigating the impact of "Le Petit Chef" on customers' dining experiences. *Technological Forecasting and Social Change*, *172*, 121051.

Dutta, R., Mantri, A., & Singh, G. (2022). Evaluating system usability of mobile augmented reality application for teaching Karnaugh-Maps. Smart Learning Environments, *9*(1), 6.

Evans, D., & Clark, P. (2021). Unity 3D development for cross-platform augmented reality applications. *Journal of Software Engineering Research*, *36*(7), 445-462

Fauziah, Y. N., Retnowati, N. D., Abadi, S., Firdaus, M., & Aji, B. S. (2023). Augmented reality: A systematic review between usability and learning experience. *Interactive Learning Environments*.

Garcia, M., & Lee, S. (2022). Prototype development of AR-based menu visualization system for restaurants. In M. Kurosu (Ed.), *Human-computer interaction. User experience and behavior* (pp. 234-248). Springer.

Gronier, G., & Baudet, A. (2021). Psychometric evaluation of the F-SUS: Creation and validation of the French version of the system usability scale. International Journal of Human-Computer Interaction, *37*(16), 1571-1582.

Harris, J., & Taylor, K. (2023). Prototyping methodologies in software engineering: An empirical study. *Software Engineering Journal*, *48*(2), 89-106.

Hatzl, J., Henning, D., Hartmann, N., Böckler, D., & Uhl, C. A. (2023). New method for common femoral arterial access using a mixed reality-assisted technique on a phantom model. Journal of Endovascular Therapy, *23*(51), 189.

Martín-Valero, R., Vega-Morales, A., Martín-Vega, F. J., Rodriguez-Huguet, M., Rodríguez-Martínez, M. C., & Vinolo-Gil, M. J. (2025). Effectiveness of augmented reality in the teaching of health university students: Quasi-experimental study. JMIR Serious Games, *13*(1), e54312.

Miller, S., Thompson, G., & Johnson, R. (2022). Augmented reality technology adoption in service industries: A systematic literature review. *Technological Forecasting and Social Change*, *145*, 118132.

Mourtzis, D., Angelopoulos, J., & Panopoulos, N. (2021). Augmented reality in food promotion and analysis: Review and potentials. *Digital*, *1*(4), 16.

Purnomo, A., & Sari, D. (2023). Customer experience challenges in traditional menu systems: An observational study of Jakarta restaurants. *Indonesian Journal of Hospitality Management*, *7*(2), 89-104.

Santos, M. E. C., Taketomi, T., Sandor, C., Polvi, J., Yamamoto, G., & Kato, H. (2014). A usability scale for handheld augmented reality. In *Proceedings of the 1st Symposium on Spatial User Interaction* (pp. 167-168). Association for Computing Machinery.

Statistics Indonesia. (2023). *Telecommunication statistics in Indonesia 2022*. Badan Pusat Statistik. https://www.bps.go.id/en/publication/2023/08/31/131385d0253c6aae7c7a59fa/telecommunication-statistics-in-indonesia-2022.html

Statistics Indonesia. (2024). *Food and beverage service activities statistics 2023*. Badan Pusat Statistik. https://www.bps.go.id/en/publication/2024/12/23/f2c7743c4712aaeaa4abf694/food-and-beverage-service-actvities-statistics-2023.html

Thompson, A., Davis, R., & Miller, K. (2021). Enhanced user engagement through 3D object visualization in interactive systems. *Interacting with Computers*, *33*(4), 298-312.

Turner, B., Anderson, L., & Cooper, J. (2023). Image tracking accuracy in mobile augmented reality: A comparative study of SDK platforms. *Virtual Reality*, *27*(2), 289-306.

Wang, Y., & Zhang, L. (2022). Digital menu systems in restaurants: Consumer acceptance and behavioral intentions. *International Journal of Hospitality Management*, *84*, Article 88-98.

Wilson, R., Parker, S., & Evans, M. (2020). Iterative development methodologies for user-centered design in mobile applications. *ACM Computing Surveys*, *53*(3), 1-35.