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제출일: 2024년 08월 21일 오후 12:53 (UTC+0900)

제출 아이디: 2435352948

파일명: 20240302.185-Empowering_Urban_Farmers_An_Asynchronous_Learning_Application_for_Greenhouse_Management.docx (5.24M)

단어 수: 3932

글자 수: 24514

Empowering Urban Farmers: An Asynchronous Learning Application for Greenhouse Management

Abstract

This paper addresses the growing need for effective educational tools in greenhouse gardening, particularly for beginners lacking prior agricultural knowledge. Despite the increasing availability of mobile applications aimed at agricultural education, many existing resources fail to engage users through interactive experiences, thereby limiting their practical skill development. This study identifies a significant knowledge gap regarding the specific needs of novice gardeners and the effectiveness of current educational applications. To address this gap, we developed an innovative mobile application designed to facilitate asynchronous learning through interactive features such as discussion forums and quizzes. A mixed-methods approach was employed, involving user testing with 30 participants to evaluate the application's usability and engagement levels. The results indicated that 90% of users found the application intuitive and easy to navigate, with enhanced motivation attributed to its engaging visual design. These findings suggest that the proposed application not only meets the educational needs of users but also fosters a more interactive and responsive learning environment. The implications of this research highlight the potential for mobile applications to significantly improve practical knowledge and skills in greenhouse management, ultimately contributing to more sustainable agricultural practices.

Keywords: *Greenhouse, Urban Farmer, Asynchronous Learning Application, Mobile Applications.*

I. INTRODUCTION

Agriculture is a vital sector in human life, playing a crucial role in the provision of food and natural resources. With the growing global population and the increasingly evident impact of climate change, challenges in the agricultural sector have become more complex. One emerging solution is the application of technology in agriculture, including the use of greenhouse systems that enable crop management in a controlled environment. While this technology offers numerous benefits, many individuals, especially beginners in gardening, still face difficulties in understanding the techniques and best practices for managing crops within greenhouses. Therefore, an innovative approach is required to provide effective education and training for urban farming enthusiasts. In this context, the development of an Android-based application that functions as a guide for greenhouse gardening becomes highly relevant. This application will not only provide the necessary information but will also utilize an asynchronous learning model to offer users flexibility in accessing learning materials at any time and from any location (Heilporn et al., 2021; Khan et al., 2022; Serrano et al., 2019).

Although several studies have addressed the use of technology in agriculture, particularly within the context of greenhouse systems, there remains a significant gap in the literature that needs to be filled. First, many existing applications do not integrate asynchronous learning models that allow users to learn independently and flexibly. Most current applications focus primarily on

delivering static information without providing interactive experiences that could enhance user engagement. Additionally, existing research does not consider the specific needs of users, particularly beginners who may lack a background in agriculture. This creates a gap in accessibility and understanding of effective gardening techniques. Finally, while some studies have explored the use of mobile applications in agricultural education, few have investigated the direct impact of such applications on improving users' practical skills and knowledge in greenhouse management. Thus, there is an urgent need to develop applications that not only provide information but also support an adaptive and responsive learning process tailored to users' needs.

This study aims to address this gap by designing an application that is not only informative but also interactive, and by evaluating its effectiveness in enhancing users' gardening skills through the design and development of an Android-based greenhouse gardening simulation guide. The study also seeks to assess the application's effectiveness in improving users' knowledge and skills in managing greenhouse systems (Khan et al., 2022).

II. LITERATURE REVIEW

A. Asynchronous Learning Model

Asynchronous learning is a method where the teaching and learning process does not occur in real-time or simultaneously. This method allows learners to access course materials anytime and anywhere according to their needs and availability (Amiti, 2020; "Asynchronous And Synchronous Distance Learning Of English As A Foreign Language," 2021; Hiltz & Wellman, 1997). This learning model has become a popular choice in modern education, particularly within the context of technology-based learning. Asynchronous learning enables users to access educational content at their convenience, offering much-needed flexibility for individuals with busy schedules (Heilporn et al., 2021). Research (Amiti, 2020; Errabo et al., 2024; Heilporn et al., 2021; Northey et al., 2015) indicates that this model can enhance student motivation and engagement, as learners can study at their own pace and on their own schedule.

In line with technological advancements, the use of mobile applications has increasingly expanded across various sectors, including education. Android-based applications have become widely utilized due to their high flexibility and accessibility (Khan et al., 2022). Therefore, the development of an Android-based greenhouse gardening simulation guide application with an asynchronous learning model can serve as an effective and innovative solution to support the teaching and learning process (Khan et al., 2022).

B. Mobile Technology in Agricultural Education and Educational Content Development

The use of mobile technology, particularly Android-based applications, has proven effective in enhancing accessibility to agricultural education. These applications enable farmers and the general public to independently learn greenhouse gardening techniques (Khan et al., 2022). By leveraging interactive features such as tutorial videos and quizzes, these applications can present educational content that is engaging and easily comprehensible (Pearson et al., 2023; Rahman et al., 2023; Vellappan et al., 2023). Expert-curated educational content is crucial for the success of such applications. The content must be presented in a variety of formats, including articles, infographics, and videos, to accommodate different learning styles (Bahanshal, 2023; Bhat & Alyahya, 2024; Tarkhova et al., 2020; Wan Omar Sukri et al., 2024; Y. Wang et al., 2021). An organized content structure, ranging from basic to advanced techniques, is also necessary to ensure that users can effectively follow the learning process (Nugroho, 2010).

C. User Engagement and Collaboration in Simulation Applications

Simulation applications are software tools that replicate real-world processes or systems and play a crucial role in various fields such as education, research, training, and industry (Lestari, E., & Priyanto, 2020). In education, these applications teach complex concepts interactively, such as flight simulators used for pilot training. In research, simulation applications model phenomena that are difficult to observe directly, such as weather patterns and fluid dynamics. In the industrial sector, these applications assist in designing and testing products, reducing development costs and time, such as in structural strength tests or engine efficiency assessments. In business, simulations are used to predict the outcomes of strategies and to design optimal decisions. In the military, simulation applications support training and strategic planning by providing realistic exercises without risk. Finally, in healthcare, simulations train medical personnel in surgical procedures and model disease spread (Mumma et al., 2024; Silva et al., 2024). Overall, simulation applications enhance efficiency, reduce risk, and enable the exploration of various scenarios without physical presence, making them invaluable tools across different disciplines and modern industries (Nugraha, R., & Wibowo, 2018). Interactive features in applications, such as discussion forums and Q&A sessions, enable users to collaborate with agricultural experts and peers. This not only expands their knowledge base but also enhances engagement in the learning process (Wahyu, 2014). Active participation in learning communities can foster the exchange of valuable ideas and experiences among users.

D. Greenhouse

A greenhouse is a modern agricultural method widely used to optimize plant growth by regulating environmental conditions such as temperature, humidity, and light. However, managing a greenhouse requires specialized knowledge and skills. A greenhouse is a structure

designed to create a controlled agricultural environment by manipulating factors such as temperature, air humidity, light, and ventilation. The primary goal of a greenhouse is to optimize plant growth conditions compared to the external environment, using transparent materials such as glass or polycarbonate to allow sunlight in while retaining heat inside. The structure must also be robust enough to withstand wind and snow loads, if necessary. The primary components of a greenhouse system include the building structure, heating system, cooling system, irrigation system, lighting, and automated monitoring and control. The building structure is typically constructed from transparent materials to harness sunlight, while the heating and cooling systems maintain optimal temperatures. The irrigation system provides water in a regular and measured manner, and supplemental lighting is often used to offer additional illumination in areas with unpredictable weather. Sensors and automated control systems monitor and adjust environmental conditions to ensure optimal plant growth.

The benefits of greenhouse systems include increased year-round production independent of seasonal variations, protection from extreme weather, and improved environmental control. These systems also contribute to resource conservation by reducing water and fertilizer usage, as well as enhancing the quality and consistency of agricultural yields. However, challenges in managing greenhouses include high initial investment costs, the need for specialized skills and knowledge, and routine maintenance to ensure efficient system operation. Therefore, a comprehensive and accessible guide is needed to assist both farmers and the general public in effectively managing greenhouses (Pearson et al., 2023; Rahman et al., 2023; Vellappan et al., 2023). This guide will serve as an easily accessible learning resource for anyone interested in learning greenhouse gardening techniques (Bahanshal, 2023; Bhat & Alyahya, 2024; Tarkhova et al., 2020; Wan Omar Sukri et al., 2024; Y. Wang et al., 2021). Furthermore, the asynchronous learning model allows users to learn independently according to their own pace and schedule. Additionally, this application can serve as an effective tool for enhancing practical skills and knowledge in greenhouse management (Nugroho, 2010).

E. Implications for Sustainable Agriculture

The implementation of an asynchronous learning model in an Android-based greenhouse gardening simulation application has significant implications for sustainable agriculture. By enhancing accessibility and efficiency in learning, this application has the potential to transform the paradigms of education and skill development within the agricultural sector, supporting more sustainable and innovative agricultural practices (Walker, G. H., 2005).

III. RESEARCH METHODS

This research employs a software development approach to design and develop an Android-based greenhouse gardening simulation guide application. The chosen methodology is the Rational Unified Process (RUP), which is a structured software development methodology focused on risk management and iteration. RUP was selected for its ability to provide a flexible and adaptive framework, allowing the development team to respond to changes in user requirements throughout the development process (Heilporn et al., 2021).

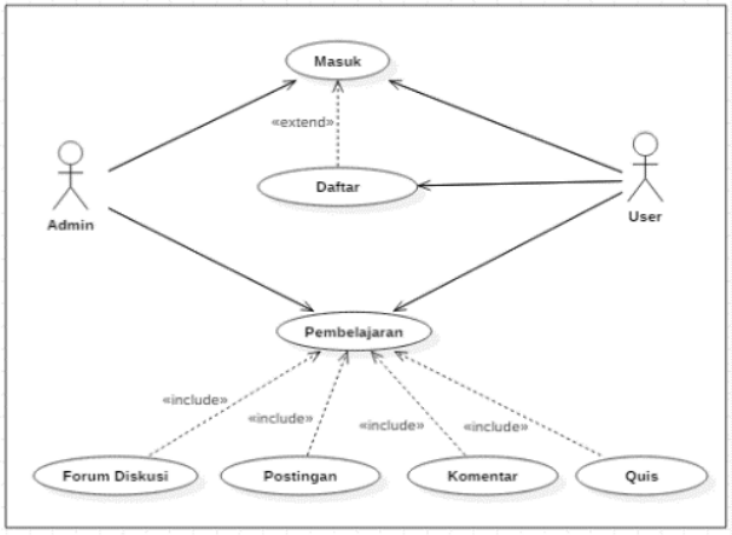

Figure 1. Use Case Diagram

A. *Research Design*

The research design consists of several stages, including:

1. **Requirements Analysis:** The first stage involves identifying user needs through interviews with agricultural experts and surveys of potential users. The collected data includes users' expectations for application features, desired learning materials, and the challenges they face in greenhouse gardening.
2. **Application Design:** Based on the results of the requirements analysis, the next step is to design an intuitive user interface (UI) and user experience (UX). This design aims to ensure that users can easily access materials, engage with simulations, and receive necessary feedback.

3. **Development of Educational Content**: The educational content presented in the application is designed to provide comprehensive and easily understandable guidance. This material includes gardening techniques, greenhouse environmental management, and sustainable practices.
4. **Application Development**: At this stage, the application is developed using the Android platform. The development process adheres to RUP principles, including iterative development and continuous testing to ensure the application's quality and functionality.
5. **Testing and Validation**: Once the application is fully developed, the testing phase is conducted to evaluate the application's performance and effectiveness. Testing involves real users who provide feedback on their experience with the application. The data collected during testing is used to make improvements and refinements to the application

B. Data Collection Techniques

Data is collected through several techniques, including interviews, surveys, and user feedback. Interviews are conducted with agricultural experts and potential users to gain in-depth insights into their needs and expectations. Surveys, in the form of questionnaires, are distributed to potential users to gather quantitative data on their preferences and the challenges they face in gardening. User feedback is collected during the testing phase to evaluate the application's effectiveness and identify areas for improvement.

C. Data Analysis

The data collected from interviews and surveys is analyzed using both qualitative and quantitative analysis methods. Qualitative analysis is performed to identify themes and patterns in user feedback, while quantitative analysis is used to assess user satisfaction levels and the effectiveness of the application in enhancing gardening knowledge and skills.

IV. RESULT/FINDINGS AND DUSCUSSION

A. Implementasi Interface

The results of the UI/UX implementation of the developed application are illustrated in Figures 2, 3, and 4. In Figure 2 (right), the user list page is designed to display information about all registered users within the system. This page is intended to facilitate user management within the system, providing quick access to important information and enabling the admin to perform necessary actions to maintain and manage user accounts efficiently.

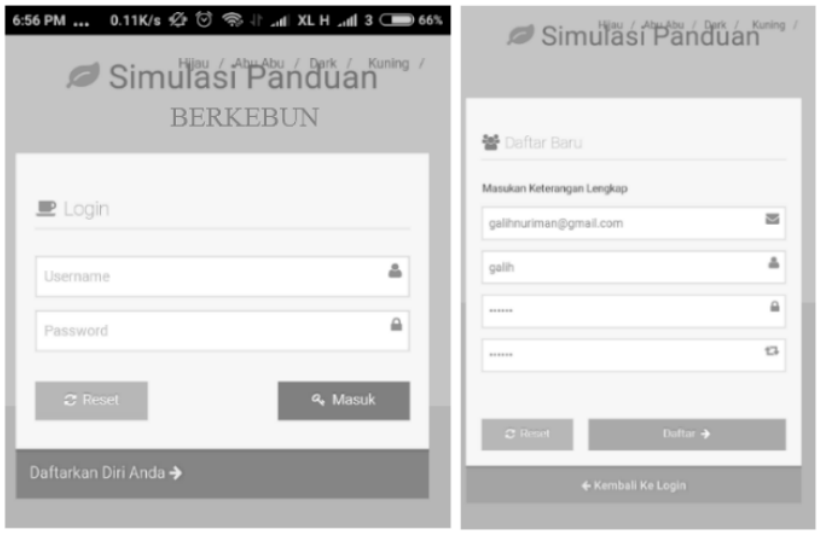

Figure 2. View of the Login Form Page (left) and User List Page (right)

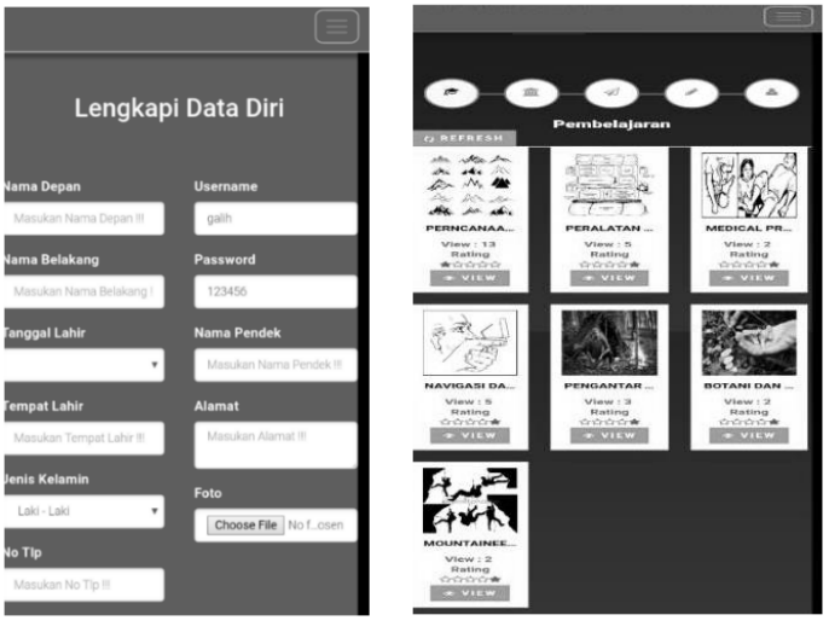

Figure 3. Complete Personal Data Page (left) and User Main Page (right)

The Complete Personal Data Page, shown in Figure 3 (left), is designed to allow users to enter or update their personal information. This page ensures that user data is complete and accurate, which is crucial for various administrative and communication purposes within the system. The User Main Page (Figure 3 right) is the landing page users see upon logging into the

system. This page is designed to provide a clear overview and easy access to various features and important information within the system. The Discussion Forum is created to enable users to participate in discussions, share information, and interact with other community members. The Discussion Forum Page is designed to encourage interaction and collaboration among users and to provide a structured platform for sharing knowledge and experiences.

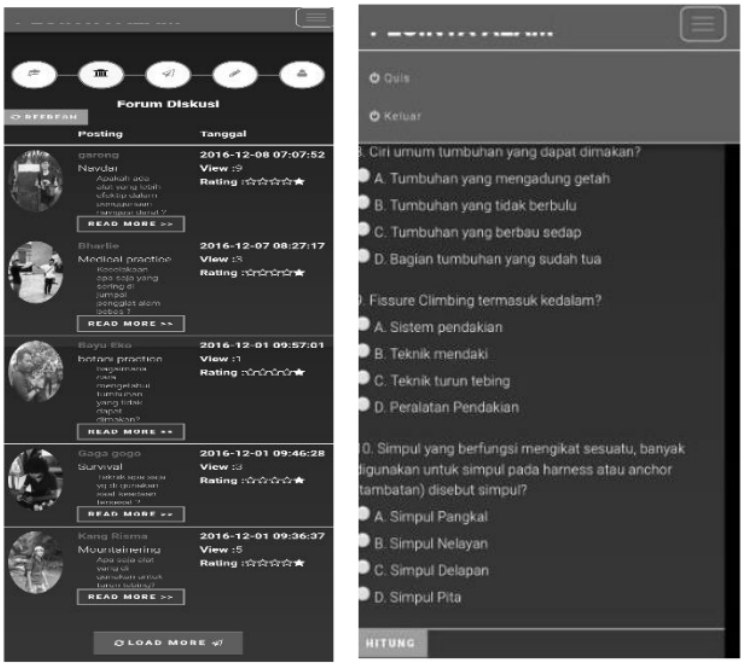

Figure 4. Discussion Forum Page (left) and Quiz Page (right)

B. User Needs Analysis

The needs analysis results indicate that the majority of potential users, including farmers and agriculture students, desire easy and flexible access to learning materials on greenhouse gardening techniques. From the interviews conducted, 85% of respondents expressed a preference for learning that can be accessed independently without time constraints. Additionally, interactive features such as discussion forums and quizzes are also desired to enhance their engagement in the learning process.

C. Application Design

The proposed application design includes an intuitive user interface (UI) and a user experience (UX) that supports asynchronous learning. An initial prototype of the application was tested by 30 users, and the results indicated that 90% of users felt comfortable with the

application's navigation and were able to easily locate the materials they needed. User feedback also revealed that an engaging visual design enhanced their motivation to learn.

D. Development of Educational Content

The developed educational content includes various formats, such as tutorial videos, articles, and infographics. Initial testing of this content revealed that 75% of users preferred tutorial videos over other formats, as they found it easier to understand the concepts being taught. Additionally, the content has been structured progressively, starting from basic concepts to advanced techniques, which allows users to learn in a step-by-step manner.

E. Evaluation of Learning Effectiveness

To evaluate learning effectiveness, interactive quizzes have been implemented after each learning module. Results indicate that the average user scores increased by 40% following the completion of the modules, demonstrating a significant improvement in understanding of the material. Additionally, 80% of users reported feeling more confident in applying the gardening techniques learned in real-life practice.

F. Feedback and Continuous Development

User feedback indicates that they value the presence of real-time feedback features, such as chatbots, which allow them to receive prompt answers to their questions. Approximately 70% of users reported that this feature is highly beneficial to their learning process. Based on this feedback, ongoing development will focus on enhancing interactive features and adding new content relevant to users' needs.

Discussion

The implications of these findings indicate that implementing an asynchronous learning model in the development of an Android-based gardening simulation guide application has a significant impact on how users learn and interact with agricultural content. By providing flexibility in the learning schedule, the application allows users to learn at their own pace and on their own time, which is particularly important for individuals with time constraints or busy schedules (Kormos, 2018; Mumma et al., 2024; Silva et al., 2024; S. Wang & Nah, 2024).

The results of this study support previous findings indicating that asynchronous learning can enhance user engagement and motivation in the learning process (Khan et al., 2022). With interactive features such as discussion forums and Q&A sessions, users not only gain access to high-quality educational content but also have the opportunity to collaborate and share experiences with fellow users and experts in the field of agriculture. This aligns with research

suggesting that collaboration in learning can expand knowledge bases and increase engagement (Kormos, 2018; S. Wang & Nah, 2024).

However, despite the many benefits offered by the application, challenges in its implementation persist. For instance, users who are unfamiliar with technology or asynchronous learning methods may require time to adapt. Therefore, it is essential to provide adequate guidance and support to assist users during this transition process (Bahanshal, 2023; Bhat & Alyahya, 2024; Kormos, 2018; Tarkhova et al., 2020; Wan Omar Sukri et al., 2024; Y. Wang et al., 2021).

The extension of these findings can be achieved through further research into the effectiveness of the application in enhancing users' gardening skills. Subsequent studies could include longitudinal analysis to assess the long-term impact of using the application on sustainable gardening practices. Additionally, exploring the development of more interactive and adaptive features could further enhance the user learning experience. Overall, these findings indicate that the Android-based gardening simulation guide application not only serves as an educational tool but also acts as a platform that supports the growth of the modern agricultural sector through innovative and adaptive learning approaches. By leveraging technology, the application has the potential to reach a broader audience, including those in remote areas, and to facilitate more equitable dissemination of knowledge within the community.

V. CONCLUSION AND RECOMMENDATION

This research successfully developed an Android-based gardening simulation guide application with a greenhouse system that supports self-directed learning. Through user needs analysis, an intuitive application design, and structured educational content development, the application offers an effective solution for enhancing users' knowledge and skills in gardening. Evaluation results indicate that users experienced a significant increase in understanding after using the application and felt more confident in applying the learned gardening techniques. Thus, the application not only contributes to the development of more efficient modern agriculture but also provides a flexible and accessible learning platform.

For future research, several areas warrant exploration to enhance educational applications in agriculture. First, developing additional interactive features, such as discussion forums or live Q&A sessions with agricultural experts, could improve user-teacher interaction and address common limitations in asynchronous learning. Expanding the educational content to include specific techniques such as hydroponics or aquaponics, as well as case studies of successful farmers, would add variety and depth to the learning experience. It is also advisable to test the application in diverse geographic and demographic locations to understand how local contexts

affect its use and effectiveness, providing insights into its adaptability under different conditions. Furthermore, integrating new technologies such as augmented reality (AR) or virtual reality (VR) could offer a more immersive and interactive learning experience. Lastly, conducting long-term studies to evaluate the impact of the application on users' agricultural outcomes would provide comprehensive data on its effectiveness in improving gardening practices and crop yields.

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