



Usability of the HarvestXplore Mobile Application for Postharvest Technology through Self-Directed Learning

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ABSTRACT

The integration of digital learning tools in higher education has become increasingly important in supporting self-directed learning, particularly in technical and vocational disciplines. This study aimed to develop and evaluate the usability of the HarvestXplore mobile application as a digital teaching aid for the Postharvest Technology course among Bachelor of Education (Agricultural Science) students. The application was developed based on the ADDIE instructional design model, encompassing the phases of analysis, design, development, implementation, and evaluation. A quantitative research design was employed, involving an online questionnaire administered to undergraduate students enrolled in the course. Usability was evaluated across four dimensions: multimedia, technical, interactivity, and content. The findings revealed high usability levels for all dimensions, with mean scores ranging from 4.45 to 4.49. The multimedia and interactivity features, including videos, quizzes, and gamification elements, significantly enhanced student engagement and learning motivation. Overall, the results indicate that HarvestXplore has strong potential as an effective digital teaching aid to support self-directed learning in postharvest education.

1. Introduction

Postharvest technology plays a critical role in maintaining the quality, safety, and marketability of agricultural produce [3,7]. Effective teaching and learning of postharvest handling require not only theoretical understanding but also clear visualisation of processes such as harvesting, grading, cooling, packaging, and storage. However, conventional lecture-based approaches often limit students' ability to fully comprehend these technical processes, particularly in higher education

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contexts where time constraints and limited access to practical facilities may hinder deeper learning [17,18].

In line with the advancement of digital technologies and the principles of Education 4.0, higher education institutions are increasingly adopting mobile learning and self-directed learning (SDL) approaches [2,4]. SDL emphasises learners' autonomy in planning, managing, and evaluating their own learning, which is essential for developing lifelong learning skills (Knowles, 1975; Zimmerman, 2002). Mobile learning applications, supported by multimedia and interactive features, offer flexible access to learning materials and have been shown to enhance learner engagement, motivation, and conceptual understanding [11,24].

In agricultural education, mobile learning has gained growing attention due to its ability to support learning beyond the classroom and laboratory [24]. Previous studies have reported that mobile applications contribute positively to students' understanding of agricultural concepts, including crop management, pest control, and postharvest handling [1,16]. Multimedia elements such as instructional videos, animations, and interactive quizzes are particularly effective in conveying complex and process-based knowledge, which is central to postharvest education [8].

The design and development of effective mobile learning applications require a systematic instructional framework. The ADDIE instructional design model, consisting of analysis, design, development, implementation, and evaluation phases, is widely used to ensure that learning materials are pedagogically sound and user-centred [13]. Numerous studies have adopted the ADDIE model in the development of educational applications due to its structured yet flexible nature, allowing continuous evaluation and improvement throughout the development process [20].

Usability is a crucial factor influencing the effectiveness of mobile learning applications. In educational contexts, usability encompasses ease of use, technical reliability, clarity of content, and learner satisfaction. Applications with high usability are more likely to support sustained learner engagement and effective self-directed learning [6]. Previous research has highlighted that poor usability, including complex navigation or technical instability, may negatively affect learners' motivation and learning outcomes [22].

Despite the increasing adoption of mobile learning in higher education, there remains a lack of context-specific digital teaching aids tailored to postharvest technology courses at the tertiary level, particularly within the Malaysian agricultural education context [19]. Most existing applications are generic in nature and do not fully align with course learning outcomes or the specific needs of technical and vocational education and training (TVET) students [14,21].

Therefore, this study addresses this gap by developing and evaluating the usability of the HarvestXplore mobile application as a self-directed learning tool for the Postharvest Technology course (VAT3013). Specifically, this study aims to identify students' learning needs, develop a mobile learning application based on those needs and course learning outcomes, and evaluate its usability in terms of multimedia, technical, interactivity, and content aspects. By integrating pedagogical principles, multimedia learning theory, and a systematic instructional design approach, this study contributes to the growing body of research on mobile learning and self-directed learning in agricultural higher education.

2. Methodology

2.1 Research Design

This study employed a developmental research design incorporating a quantitative, cross-sectional usability evaluation to achieve its objectives (Richey & Klein, 2014). The research design was selected to allow the systematic development of an educational product while simultaneously

generating empirical evidence on its suitability for instructional use (Branch, 2018). In this study, the HarvestXplore mobile application functioned not only as a learning intervention but also as the central research output, developed to address identified learning challenges in the Postharvest Technology course (VAT3013). The developmental component of the design followed the ADDIE instructional design model, ensuring that the application was pedagogically grounded, learner-centred, and aligned with course learning outcomes [10]. This approach enabled the integration of instructional analysis, structured content design, multimedia development, and iterative refinement prior to evaluation.

Following the development phase, a quantitative cross-sectional design was applied to evaluate the usability of the application from the learners' perspective. Quantitative methods were deemed appropriate as usability constructs can be measured reliably using standardised Likert-scale instruments, allowing for objective assessment and comparison across multiple dimensions (Lewis, 2018). Data were collected at a single point in time after students had experienced the application, capturing their perceptions of usability in terms of multimedia quality, technical functionality, interactivity, and content suitability (Sauro & Lewis, 2016). This design facilitated efficient data collection while providing meaningful insights into the overall usability and readiness of the application for self-directed learning implementation in higher education.

The combination of developmental research and quantitative usability evaluation ensured methodological coherence between the research objectives, the instructional product, and the evaluation process. By linking needs analysis, systematic development, and empirical usability assessment, the research design provided a comprehensive framework for determining whether the HarvestXplore application effectively supports self-directed learning in a technical and vocational agricultural education context.

2.2 Application Development

The HarvestXplore mobile application was developed using the ADDIE instructional design model, which provides a systematic framework for producing effective and learner-centred instructional materials ([10]. The development process began with the analysis phase, during which students' learning challenges, preferred learning approaches, and expectations for a mobile learning tool were identified, particularly in relation to self-directed learning in postharvest topics [24]. These findings informed the design phase, where the application structure, navigation flow, and content organisation were planned in alignment with the course learning outcomes of VAT3013. Multimedia elements such as digital notes, instructional videos, and interactive quizzes were deliberately incorporated to support visualisation of technical processes and to enhance learner engagement [12, Zarzycka-Piskorz, 2016).

During the development phase, the planned design was translated into a functional mobile learning application. Learning materials were integrated alongside interactive features, including quiz-based activities and supporting elements intended to reinforce understanding and provide immediate feedback [24]. Internal testing was conducted to ensure functional consistency, navigation stability, and basic technical reliability before the application was deployed. The implementation phase involved providing students with access to the application for learning purposes within the course context, enabling them to explore the content independently and engage with the interactive features as part of their self-directed learning experience [4]. The final evaluation phase focused on assessing the usability of the completed application, rather than learning effectiveness, to determine its suitability as a digital teaching aid in higher education [22].

2.3 Participants and Data Collection

The participants of this study consisted of undergraduate students enrolled in the Bachelor of Education (Agricultural Science) programme who were taking the Postharvest Technology course. These students were selected as they represented the intended users of the HarvestXplore application and possessed prior exposure to the course content. Data collection was conducted after the students had been given sufficient time to access and use the application, ensuring that their responses reflected actual user experience rather than initial impressions.

Data were collected using an online questionnaire administered through Google Forms. The use of an online platform facilitated efficient data collection and ensured uniform administration of the instrument across all participants (Evans & Mathur, 2018). Participation was voluntary, and students were informed that their responses would be used solely for research and improvement purposes. Anonymity was maintained to encourage honest and unbiased feedback regarding their experience with the application.

2.4 Research Instrument and Data Analysis

The research instrument consisted of a structured questionnaire designed to evaluate the usability of the HarvestXplore application. The questionnaire measured four main usability dimensions: multimedia, technical, interactivity, and content. Items were constructed to reflect key usability attributes such as clarity of presentation, ease of navigation, effectiveness of interactive features, and alignment of learning materials with course objectives (Nielsen, 1993; Tullis & Albert, 2013). Responses were measured using a five-point Likert scale ranging from strongly disagree to strongly agree, allowing for quantifiable assessment of students' perceptions.

Prior to analysis, the reliability of the instrument was assessed using Cronbach's alpha to determine internal consistency across the usability constructs (Taber, 2018). Descriptive statistical analysis was then employed to summarise the data, including mean scores and standard deviations for each usability dimension. This approach enabled a clear interpretation of students' overall perceptions of usability and facilitated comparison across dimensions. The use of descriptive statistics was considered appropriate given the study's focus on usability evaluation rather than hypothesis testing, providing practical insights into the strengths and readiness of the application for instructional use in self-directed learning contexts (Lewis, 2018).

3. Results

3.1 Analysis Phase

This phase identified user needs via an online questionnaire (Google Forms) completed by 23 purposively sampled Agricultural Science students who took the Postharvest Technology course (VAT3013) at UPSI. The questionnaire covered five sections:

Section A: Demographics: Gender, year of study, course experience, prior use of learning apps.

Section B: Prior Knowledge: Self-rated understanding of key postharvest topics on a 5-point Likert scale.

Section C: App Needs: Agreement on app usefulness, preferred learning aids (notes, videos, quizzes, etc.), and desired features (user-friendly, simple, etc.).

Section D: Learning Style & Tech Use: Frequency of smartphone use for learning, comfort with self-learning via apps, and preferred digital learning platforms.

Section E: Challenges & Expectations: Main obstacles in understanding postharvest topics and suggestions for the HarvestXplore app.

Descriptive analysis of the responses guided the targeted design of the application's content and features.

Section A: Demographic Information

This section aimed to collect respondent profile information including gender, semester of study, VAT3013 course enrollment, and use of mobile applications for self-directed learning.

1. Gender

Of the 23 respondents, the majority were female, totaling 16 individuals (69.6%), while male respondents numbered 7 individuals (30.4%).

2. Semester of Study

The majority of respondents were from semester seven, namely 17 individuals (73.9%), followed by semester five with 3 individuals (13%), semester eight with 2 individuals (8.7%), and semester six with 1 individual (4.3%).

3. Enrollment in VAT3013 Course

All 23 respondents (100%) had taken the VAT3013 Postharvest Technology course from semester five to eight, enabling them to provide accurate and valuable feedback based on their actual learning experiences.

4. Use of Mobile Applications

A total of 13 respondents (56.5%) had never used mobile applications for self-directed learning, while 10 respondents (43.5%) had used them. This finding indicates the need to develop a user-friendly HarvestXplore application to attract students' interest in utilizing technology for learning.

Section B: Prior Knowledge of Post-Harvest Topics

This section aimed to identify students' prior knowledge levels regarding eight main aspects of post-harvest management using a five-point Likert scale, serving as a guide for determining the content and focus of HarvestXplore application development.

1. Understanding of Post-Harvest Concept

A total of 13 respondents (56.5%) understood, 8 respondents (34.8%) understood very well, while 1 respondent (4.3%) was unsure and 1 respondent (4.3%) did not understand.

2. Understanding of Harvesting Topic

A total of 13 respondents (56.5%) understood, 7 respondents (30.4%) understood very well, and 3 respondents (13%) were unsure.

3. Understanding of Cleaning Topic

A total of 12 respondents (52.2%) understood, 8 respondents (34.8%) understood very well, and 3 respondents (13%) were unsure.

4. Understanding of Grading Topic

A total of 10 respondents (43.5%) understood, 8 respondents (34.8%) understood very well, 4 respondents (17.4%) were unsure, and 1 respondent (4.3%) did not understand. This finding indicates the need for greater emphasis in the HarvestXplore application.

5. Understanding of Sorting Topic

A total of 12 respondents (52.2%) understood very well, 8 respondents (34.8%) understood, and 3 respondents (13%) were unsure.

6. Understanding of Produce Treatment Topic

A total of 8 respondents (34.8%) understood, 7 respondents (30.4%) understood very well, 6 respondents (26.1%) were unsure, and 2 respondents (8.7%) did not understand. This finding indicates a clear need to emphasize the produce treatment topic in the development of the HarvestXplore application.

7. Understanding of Pre-cooling Topic

A total of 11 respondents (47.8%) understood, 6 respondents (26.1%) understood very well, 5 respondents (21.7%) were unsure, and 1 respondent (4.3%) did not understand. This moderate level of understanding requires emphasis on the pre-cooling topic.

8. Understanding of Storage Topic

A total of 11 respondents (47.8%) understood very well, 9 respondents (39.1%) understood, 2 respondents (8.7%) were unsure, and 1 respondent (4.3%) did not understand.

Section C: Needs for Learning Applications

This section aimed to identify students' needs regarding learning applications for post-harvest topics.

1. Mobile Applications Help Understanding

A total of 18 respondents (78.3%) strongly agreed and 5 respondents (21.7%) agreed that mobile applications can help them understand post-harvest topics.

2. Required Learning Materials

Respondents could select more than one option: demonstration videos (18 respondents, 78.3%), digital notes (17 respondents, 73.9%), animations/simulations (13 respondents, 56.5%), revision quizzes (11 respondents, 47.8%), and forum space (3 respondents, 13%).

3. Expected Key Features of Application

Respondents could select more than one option: concise and compact content (17 respondents, 73.9%), customized according to course topics (14 respondents, 60.9%), user-friendly interface (15 respondents, 52.2%), offline accessibility (12 respondents, 52.2%), and reward/badge system (7 respondents, 30.4%).

Section D: Learning Styles and Technology Use

This section aimed to identify students' learning styles and level of technology use in the context of self-directed learning.

1. Use of Smartphones for Learning

A total of 15 respondents (65.2%) very frequently used smartphones, 6 respondents (26.1%) frequently used, and 2 respondents (8.7%) sometimes used them for learning purposes.

2. Self-Directed Learning Without Supervision

A total of 19 respondents (82.6%) felt very comfortable learning independently through digital applications without lecturer supervision, while 4 respondents (17.4%) disagreed.

3. Digital Learning Platforms

Respondents could select more than one option: mobile applications (19 respondents, 82.6%), YouTube (12 respondents, 52.2%), websites (10 respondents, 43.5%), and Google Classroom (5 respondents, 21.7%).

Section E: Learning Challenges and Expectations Towards HarvestXplore

This section aimed to identify the main challenges students face in understanding post-harvest topics and their expectations for the development of the HarvestXplore application.

1. Challenges in Understanding Post-Harvest Topics

Respondents could select more than one option: lack of teaching materials (15 respondents, 65.2%), difficulty understanding theory (12 respondents, 52.2%), time constraints (9 respondents, 39.1%), and lack of interest in the topic (1 respondent, 4.3%).

2. Suggestions

Respondents' suggestions included providing concise and easy-to-understand notes, emphasizing post-harvest handling practical work for self-directed learning outside lecture hours, and adding game or interactive elements to enhance motivation and understanding of post-harvest topics.

3.2 Design Phase

Based on the analysis findings, the design phase began by planning the overall structure of the HarvestXplore application using Jotforms software. Learning objectives were clearly and focusedly outlined, while the application structure was divided into stages to determine what students need to know, understand, and apply after using the application. This arrangement provides systematic guidance in content development and ensures each learning element aligns with student needs and course learning outcomes.

In the design phase, two main learning theories, namely Cognitive Theory and Constructivism Theory, served as the foundation. Based on Cognitive Theory, the application was designed with systematic content organization and the use of multimedia elements such as concise text, graphics, audio, and appropriate colors to aid the process of information reception, storage, and recall. The application of Constructivism Theory is emphasized through interactive learning activities such as

quizzes, staged content exploration, and the use of an AI Chatbox that allows students to build their own understanding based on experience and interaction with the application.

Emphasis was placed on multimedia, content, technical, and interactive aspects. The HarvestXplore application consists of subtopics within the Postharvest Technology course for the Postharvest Handling topic, namely grading, produce treatment, cooling, and storage. Application content includes mind maps based on the Standard Reference Guide for Agricultural Products Under GPL Regulations and Federal Agricultural Marketing Board Regulations, learning videos, quizzes, and an AI Chatbox.

Among the main screens designed are:

- Home Page: Display of self-introduction and supervisor lecturer, interesting facts via brief slides, quick access icons to all important functions according to learning topics, and an AI chatbox button.
- Interactive Notes Display: Developed in the form of mind maps and visualizations related to learning topics in brief slide display format.
- Postharvest Demonstration Videos: Short learning videos (microlearning) with a duration of 15–20 minutes for each postharvest handling subtopic.
- HOTS Quiz Activities: Multiple-choice quizzes with questions based on High-Order Thinking Skills (HOTS) levels and immediate feedback.
- AI Chatbox: An artificial intelligence (AI)-based chatbot built into the Jotform platform.

The design of all the above screens is guided by the usability principles of Jakob Nielsen (1993), which emphasize effectiveness, efficiency, and user satisfaction (Nielsen Norman Group).

3.3 Development Phase

The development phase is the stage where all planning from the design phase is translated into a digital prototype of the HarvestXplore application. The application was developed using Jotform as the main platform, with the integration of other software such as YouTube (video content), Wayground and Blooket (quizzes), and Napkin AI (mind map note creation).

The main interface of the application was designed with an introduction to the developer and supervisor before the main page display (Figure 1 & 2). The "next" button leads the user to the main page which houses main icons such as interesting facts, demonstration videos, learning topics, and an AI Chatbox.

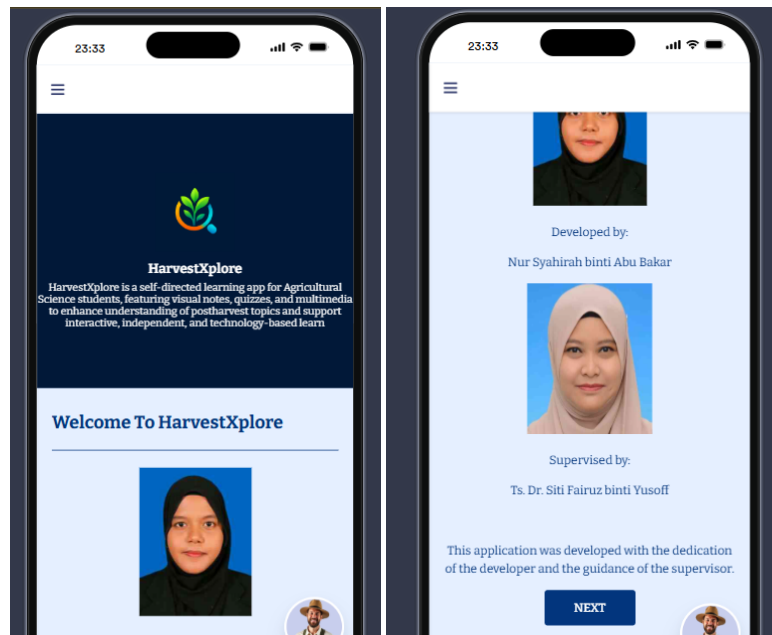


Fig. 1. Jotform Software display for HarvestXplore application development

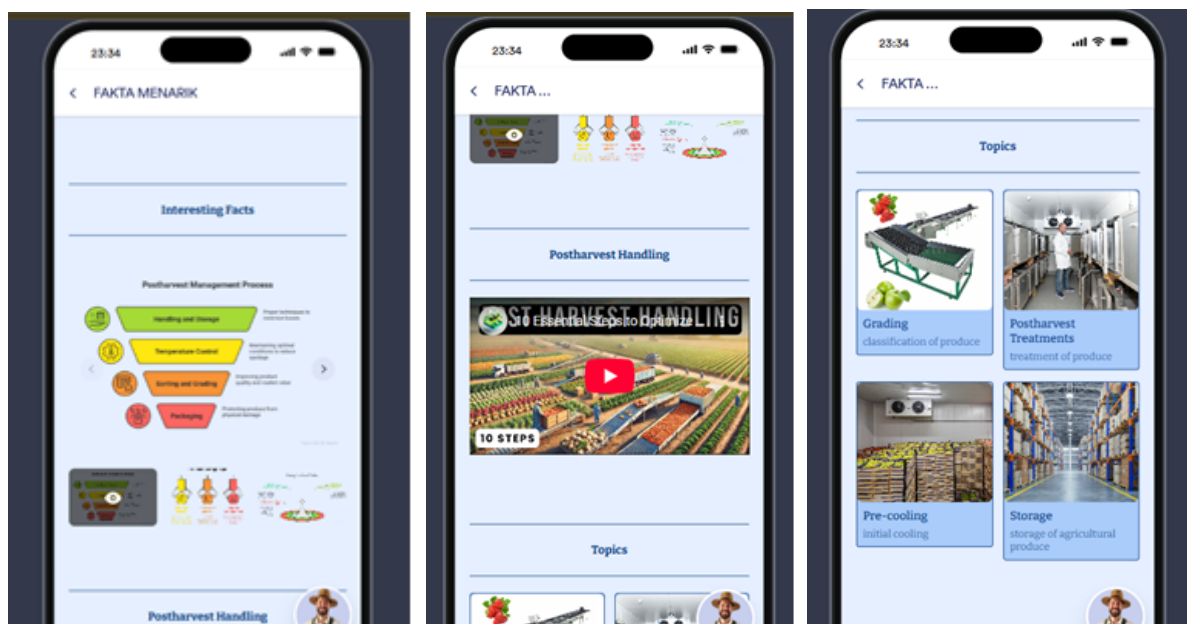


Fig. 2. Three main page displays of the HarvestXplore Application

Learning notes were produced in the form of interactive mind maps using Napkin AI, with a vertical scroll layout for easier reading (Figure 3).

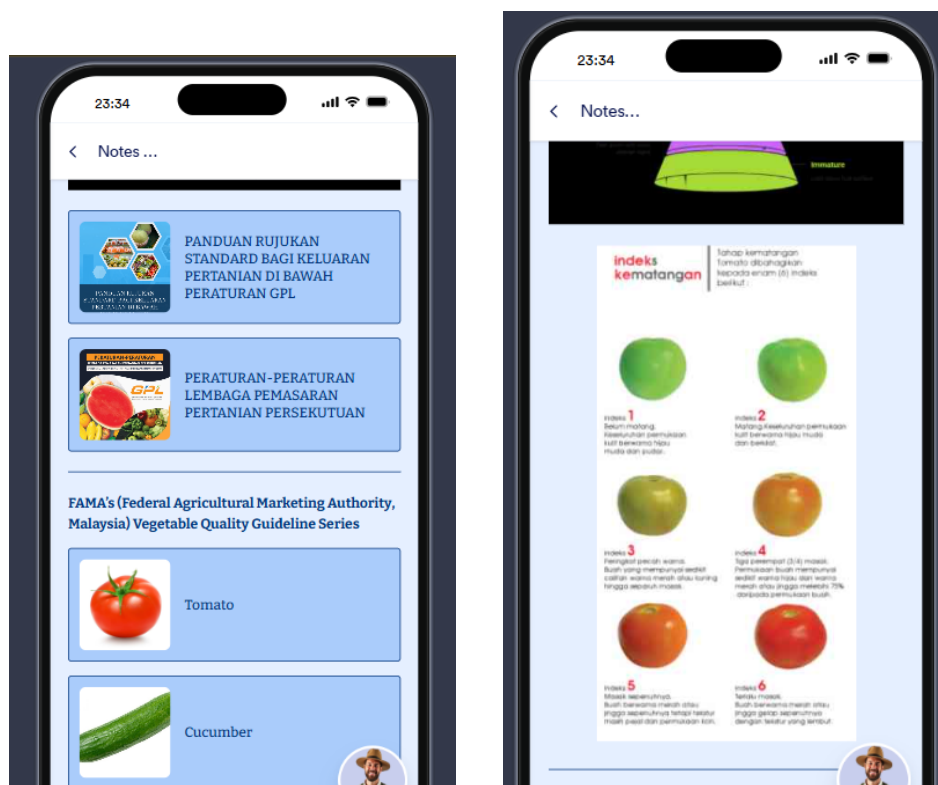


Fig. 3. Note display and content design of notes

The video section was developed with a vertical scroll function, and videos are linked from YouTube (Figure 4).

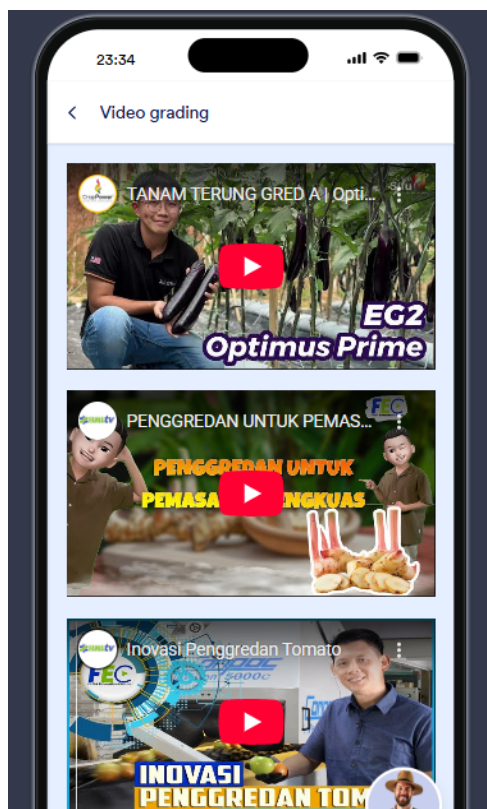


Fig. 4. Learning video display in the HarvestXplore application

Interactive quizzes were created using Blooket and Wayground software linked within the application as depicted in Figure 5.

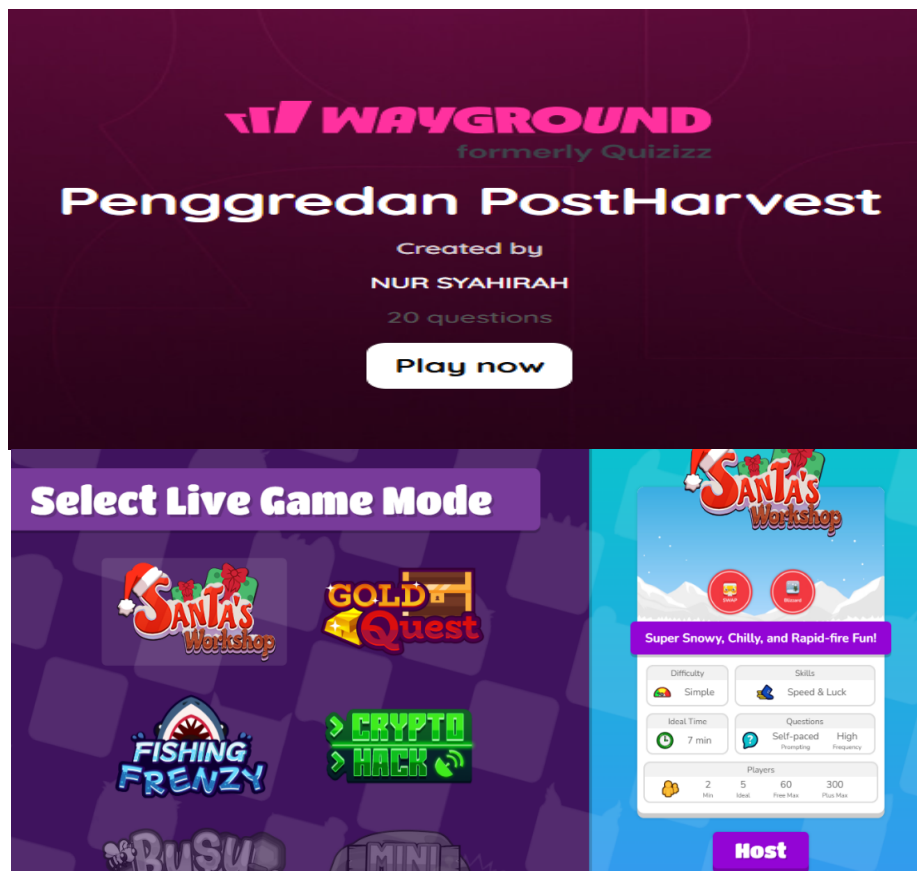


Fig. 5. Display of Blooket and Wayground Software used for learning quizzes

Figure 6 shows the AI Chatbox is placed in the bottom right corner of each page for inquiries related to learning topics.

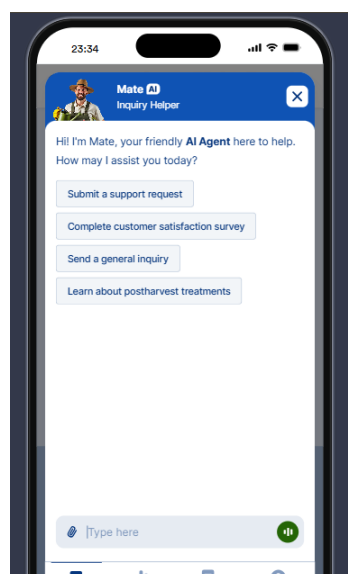


Fig. 6. Display of AI Chatbox in the bottom right corner of each page

Configuration of interactive elements was done in the Jotform App Builder using "Action" settings such as "Navigate to Page" and "Visit URL". Functionality testing was conducted to ensure every button, navigation, video, note, quiz, and AI Chatbox functioned properly. After the application was developed, a questionnaire to study the application's usability in terms of multimedia, technical, interactive, and content aspects was evaluated by three expert lecturers from the Faculty of Technical and Vocational, UPSI, for content validation purposes.

3.4 Implementation Phase

The implementation phase is divided into a pilot study and the actual study. The pilot study involved 13 ISMP Agricultural Science students who had taken the VAT3013 course. The pilot study instrument was a Google Forms questionnaire. Students were given 2 weeks to use the application before providing feedback on the questionnaire. Improvements were made based on the feedback received.

The questionnaire was also reviewed by a panel of three experts for content validity. The reliability of the instrument was assessed using SPSS Statistics version 27 by calculating the Cronbach's Alpha value. The overall value achieved was 0.7, indicating an acceptable level of reliability (Nunnally & Bernstein, 1994).

The reliability analysis results from the pilot study indicate that the Cronbach's Alpha coefficient values for each construct are at a satisfactory to excellent level (Table 1). For Section B, which pertains to the multimedia aspect, the obtained Cronbach's Alpha value is 0.905, indicating a very high level of reliability for its seven question items. Next, Section C, covering the technical aspect, recorded a Cronbach's Alpha value of 0.913, signifying that its seven question items possess excellent internal consistency. For Section D, the interactive aspect, the recorded Cronbach's Alpha value is 0.920, thus demonstrating a very good and stable level of reliability, also comprising seven question items. Meanwhile, Section E, which evaluates the content aspect, obtained a Cronbach's Alpha value of 0.759, which is at an acceptable and sufficient level for use in the actual study, with seven question items. Overall, this analysis shows that the questionnaire instrument used has a high level of internal consistency and meets the reliability criteria as suggested by Hair et al. (2010). These obtained values prove that the questionnaire is appropriate and can be used for data collection purposes in the actual study. Table 1 respectively display the Cronbach's Alpha values for each construct and the average reliability scores obtained from the pilot study.

Table 1
Cronbach's Alpha Values for the pilot study

Construct	Cronbach's Alpha Value	Number of Items
Multimedia	0.905	7
Technical	0.913	7
Interactive	0.920	7
Content	0.759	7
Average Value	0.867	28

3.5 Evaluation Phase

3.5.1 Multimedia aspect

The descriptive analysis of seven multimedia items indicates a *very high* level of usability, with an overall mean score of 4.49 and a standard deviation of 0.49 (Table 2). Item B4 (text is easy to read) recorded the highest mean score (M = 4.56), followed by B7 (clear image resolution) (M = 4.55) and B5 (videos support learning objectives) (M = 4.51). These findings suggest that the multimedia elements in the HarvestXplore application are clear, visually appealing, and effective in supporting students' self-directed learning.

Table 2
 Interpretation data for multimedia aspect

Item	Statement	Mean	Standard Deviation	Interpretation
B1	The overall graphic design of the application looks professional	4.48	0.67	Very High
B2	The colour selection of the application is consistent with the application theme	4.45	0.59	Very High
B3	The layout of screen elements is easy to navigate	4.37	0.72	Very High
B4	The displayed text is easy to read	4.56	0.52	Very High
B5	The videos used support the learning objectives	4.51	0.65	Very High
B6	The audio used is clear	4.48	0.63	Very High
B7	The image resolution is clear	4.55	0.63	Very High
Overall Mean		4.49	0.49	Very High

3.5.2 Technical aspect

The descriptive analysis of seven technical items shows a *very high* level of usability, with an overall mean score of 4.45 and a standard deviation of 0.56 (Table 3). Item C7 (clear icon size) recorded the highest mean score (M = 4.59), followed by C4 (easy accessibility via device) (M = 4.54). These results confirm that HarvestXplore demonstrates strong technical performance, ease of access, and user-friendly design.

Table 3
 Interpretation data for technical aspect

Item	Statement	Mean	Standard Deviation	Interpretation
C1	The navigation buttons are easy to understand	4.36	0.75	Very High
C2	The application does not take a long time to access	4.37	0.83	Very High
C3	I can use this application without assistance from others	4.40	0.79	Very High

C4	The application is easily accessible via my device	4.54	0.57	Very High
C5	The flow of information presentation is not confusing	4.44	0.71	Very High
C6	The application runs smoothly without interruptions or errors	4.41	0.84	Very High
C7	The icon size is clear and easy to view on the device screen	4.59	0.51	Very High
Overall Mean		4.45	0.56	Very High

3.5.3 Interactive aspect

The analysis of seven interactive items reveals a *very high* usability level, with an overall mean score of 4.49 and a standard deviation of 0.45 (Table 4). Items D1 (engaging interactive activities) and D7 (gamification elements increase motivation) recorded the highest mean scores (M = 4.56). These findings indicate that interactive components such as quizzes, gamification, and immediate feedback successfully enhance students' engagement and motivation in self-directed learning.

Table 4
 Interpretation data for interactive aspect

Item	Statement	Mean	Standard Deviation	Interpretation
D1	The application provides interesting interactive activities	4.56	0.61	Very High
D2	The application encourages me to participate actively	4.51	0.55	Very High
D3	I can interact with multimedia elements in the application	4.37	0.70	Very High
D4	The application provides immediate feedback after actions	4.39	0.66	Very High
D5	The application allows me to test my level of understanding	4.55	0.61	Very High
D6	Interaction in the application helps me stay focused	4.45	0.61	Very High
D7	The application provides gamification elements that increase my learning motivation	4.56	0.59	Very High
Overall Mean		4.49	0.45	Very High

3.5.4 Content Aspect

The descriptive analysis of seven content items indicates a very high level of usability, with an overall mean score of 4.49 and a standard deviation of 0.43 (Table 5). Item E6 (easy-to-understand language) recorded the highest mean score (M = 4.54), followed by E2 (notes support understanding) and E3 (mind maps provide overall understanding) (M = 4.50). These results demonstrate that the content of the HarvestXplore application is relevant, clear, and well aligned with the learning outcomes of the Postharvest Technology (VAT3013) course.

Table 5
 Interpretation data for content aspect

Item	Statement	Mean	Standard Deviation	Interpretation
E1	The selected topics are critical for this course	4.48	0.63	Very High
E2	The provided notes help my understanding	4.50	0.63	Very High
E3	The mind maps help me gain an overall overview of the topic	4.50	0.59	Very High
E4	The exercises/quizzes are suitable for the topic content	4.48	0.63	Very High
E5	Videos for each topic help me understand the content more deeply	4.44	0.72	Very High
E6	The language used in the application is easy to understand	4.54	0.55	Very High
E7	The content is relevant and aligned with the course learning outcomes	4.49	0.63	Very High
Overall Mean		4.49	0.43	Very High

3.5.5 Usability Evaluation of HarvestXplore

The usability evaluation yielded consistently positive responses across all assessed dimensions. As shown in Table 6, the average mean scores for each evaluated aspect are as follows. Technical Aspect (Ease of Navigation) recorded a mean score of 4.45, indicating that students were able to access and navigate the application with minimal difficulty. Content Aspect (Understanding) achieved a mean score of 4.49, suggesting that the instructional materials were clear, well-structured, and effective in supporting students' comprehension of postharvest handling procedures. Interactive Aspect (Engagement) recorded the highest mean score of 4.49, which reflected strong student engagement with interactive components such as quizzes, videos, and mind maps. Multimedia Aspect (Visual Presentation) also achieved a high mean score of 4.49, demonstrating the effectiveness of visual and multimedia elements.

Overall, it shows that 100% of respondents reported positive learning experiences when using *HarvestXplore*, demonstrating a very high level of usability and learner acceptance of this interactive learning application.

Table 6
 Usability evaluation of HarvestXplore

Usability Dimension	Mean Score
Technical Aspect (Ease of Navigation)	4.45
Content Aspect (Understanding)	4.49

Usability Dimension	Mean Score
Interactive Aspect (Engagement)	4.49
Multimedia Aspect (Visual Presentation)	4.49

Legend: Mean scores were interpreted using a five-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree).

4. Discussion

4.1 Needs Analysis of HarvestXplore Application Development

Findings from the analysis of 23 respondents indicated that students require additional learning support for post-harvest topics, particularly in produce treatment (26.1% unsure, 8.7% did not understand) and cooling (21.7% unsure, 4.3% did not understand). The majority of respondents (78.3%) strongly agreed that a mobile application could aid their understanding, aligning with previous studies emphasizing the effectiveness of mobile-based learning in enhancing student comprehension (Kamaruddin & Abdullah, 2023). In terms of learning materials, respondents expressed a need for digital notes (73.9%), demonstration videos (78.3%), animations/simulations (56.5%), and revision quizzes (47.8%). Key desired features included concise content (73.9%), a user-friendly interface (52.2%), and offline accessibility (52.2%). These findings are consistent with Ismail et al. (2024), which highlighted the importance of interactive and user-friendly educational app design in boosting student motivation for self-directed learning.

4.2 Development of the HarvestXplore Application

The HarvestXplore application was developed using the Jotform Apps platform, integrating various multimedia elements such as text, graphics, interactive mind maps (Napkin AI), instructional videos (YouTube), interactive quizzes (Wayground and Blooket), and an AI Chatbox. The application's content covers four main topics: grading, produce treatment, pre-cooling, and storage, aligning with the learning outcomes of the Postharvest Technology (VAT3013) course. The development was grounded in a self-directed learning approach, where students play an active role in controlling their learning process. Gamification elements were incorporated through Blooket and Wayground to boost student motivation and engagement, consistent with Bandura's Social Cognitive Theory (1986), which emphasizes the role of self-efficacy in learning.

4.3 Usability Level of the HarvestXplore Application

Findings from 80 respondents showed the usability level of the HarvestXplore application to be very high across all assessed aspects. For the multimedia aspect (M=4.49), the graphic design, color scheme, layout, text, videos, audio, and image resolution were found to be clear, professional, and engaging. The use of interactive mind maps via Napkin AI facilitated students' understanding of conceptual relationships visually, supporting Hidayat et al. (2021) on the importance of visualization in STEM education. Technically (M=4.45), the app was easily accessible across various devices, featured intuitive navigation buttons, and functioned smoothly. Accessibility without a login process allowed students to access content immediately, aligning with universal design principles in learning (OECD, 2023). The interactive aspect (M=4.49), enhanced by gamified quizzes, an AI Chatbox, and immediate feedback, successfully increased student engagement and motivation. This finding supports Constructivism Learning Theory, which emphasizes the importance of active interaction in

knowledge construction [16]. Lastly, the content aspect (M=4.49), comprising digital notes, mind maps, demonstration videos, and quizzes, was relevant and aligned with the VAT3013 course learning outcomes. The use of easy-to-understand language (M=4.54) facilitated students' self-mastery of post-harvest topics, paralleling Nguyen et al. (2022) on the importance of content readability in learning applications.

4.4 Implications of the Study

The findings demonstrate that the HarvestXplore application has the potential to be an effective self-directed learning platform for the Postharvest Technology course. The balanced integration of multimedia, technical, interactive, and content elements produced an application that not only facilitates conceptual understanding but also enhances student motivation and interest in post-harvest topics. A practical implication is for VAT3013 course instructors to consider using HarvestXplore as a supplementary teaching aid, while students can utilize it for self-directed learning outside of class hours. The development of such applications aligns with the nation's digital education transformation towards flexible, student-centered 21st-century learning.

In conclusion, the HarvestXplore application demonstrates a very high level of usability and effectiveness in supporting self-directed learning for the Postharvest Technology (VAT3013) course. The high mean scores across multimedia (4.49), technical (4.45), interactive (4.49), and content (4.49) aspects prove that its systematic, ADDIE Model-based design significantly contributed to its effectiveness. The integration of clear multimedia and interactive features successfully increased student engagement, motivation, and understanding [11,24]. This supports previous studies indicating that interactive digital materials promote active learning and autonomy [15]. Ultimately, these findings support the use of applications like HarvestXplore as effective teaching aids in technical and vocational education, particularly in agriculture.

5. Conclusion

This study demonstrated that the HarvestXplore mobile application possesses a high level of usability and strong potential as a digital teaching aid for the Postharvest Technology course in higher education. The consistently high mean scores across multimedia, technical, interactivity, and content dimensions indicate that the application successfully meets learners' needs and supports self-directed learning in a technical and vocational education context.

The findings highlight the importance of integrating well-designed multimedia elements, stable technical features, and meaningful interactivity in mobile learning applications to enhance student engagement and understanding of complex postharvest concepts. The alignment of content with course learning outcomes further reinforces the pedagogical value of the application and ensures its relevance to the curriculum.

In addition, the use of the ADDIE instructional design model provided a systematic and effective framework for developing a user-centred learning application that balances pedagogical principles with usability considerations. This approach can serve as a practical reference for educators and instructional designers seeking to develop similar mobile learning tools in agricultural education and other technical disciplines.

Future research is recommended to examine the impact of HarvestXplore on students' learning performance, knowledge retention, and practical skills acquisition through experimental or quasi-experimental designs. Expanding the application to include additional postharvest topics and

implementing it across different institutions may also enhance its generalisability and contribution to digital learning in agricultural education.

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Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding the publication of this paper. No financial support, grants, or other forms of compensation were received that could have influenced the outcomes of this work. The research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Data Availability Statement

All data generated or analyzed during this study are included in this published article. Additional datasets are available from the corresponding author upon reasonable request. Where applicable, publicly available datasets used in the study are cited in the references.

Ethics Statement

This study was conducted in accordance with the ethical standards of the institutional and/or national research committee. Ethical approval was obtained where required, and informed consent was obtained from all participants involved in the research.

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