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A MOBILE LEARNING APPLICATION TO FOSTER SUSTAINABLE AGRICULTURE THROUGH HYDROPONICS: DEVELOPMENT AND USABILITY TESTING

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Abstract:

This study explores the development and usability testing of a mobile learning application tailored to provide an engaging educational experience in hydroponics for school children aged 12 years and below. The challenges faced by the agricultural education sector in capturing the interest and participation of the younger generation, where conventional methods have often struggled to engage and inspire. Embracing the principles of design thinking, this research seeks to bridge the gap in agriculture education, addressing the unique needs and preferences of younger learners in the digital age. A mobile learning application was developed, designed to combine the principles of hydroponics with interactive digital learning experiences. The design thinking methodology guided the iterative development process, placing a strong emphasis on user-centred design. The usability of the mobile learning application was assessed using the Post-Study System Usability Questionnaire (PSSUQ). Results of the usability testing revealed high levels of usability and user satisfaction among participants. The application's usefulness, user-friendly interface, engaging content, that aligned with educational objectives were among the factors contributing to its positive reception. The mobile learning application serves as a promising solution to enhance agriculture education, making hydroponics an accessible and engaging subject for school children. As a result, this research contributes to the broader goal of fostering sustainable agriculture and environmental consciousness among future generations.

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Keywords:

Agriculture Education, Hydroponics, Mobile Learning Application, Design Thinking, Usability Testing

Introduction

Background

The agriculture sector is one of the contributing sectors to Malaysia's economy. This sector plays a very important role in national food security. However, the agricultural sector in Malaysia faces challenges when the agricultural community is more pioneered by the elderly in the range of 55 to 65 years. The younger generation today is less interested in the agricultural sector even though that had good perceptions in terms of income, social status, and work convenience but not in terms of career development and warranty of future life (Widiyanti, Setyowati, & Ardianto, 2018).

The younger generation considers non-agricultural sectors such as the services, manufacturing, and construction sectors to be more prestigious than the agricultural sectors (Susilowati et al, 2012). The decline in agriculture sector interest among younger generations can affect the sustainable development of Malaysia's agricultural sector. With the increase in population resulting in an increase in food demand, an increase in production productivity is sorely needed. According to Widiyanti, Setyowati, and Ardianto (2018), declining interest of the younger generation in agriculture has led to low productivity due to dependence on older producers.

Apart from interest, knowledge about agriculture is also found to be decreasing among the younger generation nowadays. For example, they know milk is bought from a store, but they do not understand that the milk comes from cows (Boleman & Burrell, 2003). This shows the younger generation today is taking it easy and not paying attention to the agricultural activities around them. This problem is compounded by the stigma, perceptions, attitudes, and negative views of the younger generation (Susetyo et al., 2023) who consider agriculture just a farmer, rice fields, trees, cows, goats, chickens, dirty, smelly, and hot. Thus, it is very important that the younger generation needs to be educated with agricultural knowledge for the sustainability of the agricultural sector in the future. A positive attitude and passion for agriculture must be formed from early age.

The aim of this study is to; i) design and develop an educational mobile application for school children to engage and learn hydroponics practice, and ii) test the usability of the mobile application in a field.

Literature Review

According to Seo (2018), agriculture education needs to be attained from early childhood to make children know and aware about agriculture, realize the importance of agriculture, have interest in agriculture and participate in agriculture. Agriculture education is very important to make sure the right understanding and attitude toward agriculture can be developed among our young generation. In the era of industrial 4.0, engaging children with technology like mobile applications is one of the best ways to provide better learning mechanism that can improve children learning process and attract them. For example, there is a smart app that have been

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developed to help educate children on farm danger (Reid at al, 2018). According to Winsen, Setiabudi and Tjahyana (2013), mobile learning application is more exciting and flexible for user to interact with thus enrich the learning experience of the user.

Research on educational technology for promoting agriculture education highlights its significant impact on knowledge acquisition and engagement. Studies have shown that educational technology offer convenient access to agricultural content, enabling learners to explore various topics related to farming, crop management, and sustainable practices (Becker & Lande, 2023; Thar, Ramilan, Farquharson, Pang, & Chen, 2021; Garzón, Baldiris, Acevedo, & Pavón, 2020). The interactive nature of these educational technology captivates learners and promotes active participation. Overall, educational technology emerges as a promising avenue for promoting agriculture education among school children, equipping them with vital knowledge and fostering their interest in the field.

Mobile learning (m-learning) is the use of mobile devices, such as smartphones and tablets, to deliver educational content and experiences. M-learning has the potential to revolutionize agriculture education by making it more accessible, engaging, and effective. One of the biggest advantages of m-learning is that it can be accessed anywhere, anytime. This is especially beneficial for farmers who may not have the time or resources to travel to a traditional classroom. M-learning can also be more engaging than traditional methods of education, as it can incorporate multimedia content, such as videos, images, and interactive exercises. In addition to being more accessible and engaging, m-learning can also be more effective than traditional methods of education. Studies have shown that students who use m-learning tend to retain more information and have better learning outcomes (Bernacki, Greece, & Crompton, 2020; Klimova, 2019). This is likely because m-learning is more personalized and allows students to learn at their own pace.

Previous Studies
Knowledge transfer is one of the efforts to improve the interests of young generations in the agricultural sector. Knowledge about hydroponics technology can be transferred in many ways with support from effective tools that able to attract learner's attention and easy to understand. Previously Applanaidu, Kamaruddin, and Samah (2018) has developed Kad Imbas Tersusun Hidroponik UUM Sintok (KIT-Hip, UUM Sintok). KIT-Hip, UUM Sintok is an effective memory-aid tool to assist any level of users to adapt the hydroponic technology easily and quickly. Advantages of using these flashcards are (i) attractive and colourful, (ii) simple and easy way to follow the UUM Sintok hydroponic technique, and (iii) easy to bring anywhere since it is small sized and light weight.

Figure 1: Previous Innovation (KIT-Hip, UUM Sintok)

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In agriculture education, one notable market segment that is less explored was the younger generation. From a preliminary study, this younger generation market appeared to have remained largely untapped for several reasons. Firstly, the current hydroponic kit available in the market failed to pique the interest of potential young users. It lacked the necessary elements to make it an effective educational tool, particularly in the context of the digital learning era. Additionally, the existing hydroponic kit faced challenges when attempting to capture the attention of children aged 12 and below. Factors such as its size, color, and a lack of distinct selling points made it less appealing to this specific demographic. It became evident that there was an opportunity to develop a hydroponic kit that not only addressed the unique educational needs of the younger generation but also offered distinctive features that would resonate with this age group. This realization underscores the motivation and rationale behind our study, which focuses on the design and usability testing of a mobile learning application tailored to engage and educate school children in hydroponics.

Phase 1: Mobile Application Development

Method: Design Thinking

This study adopted the Design Thinking method to create a mobile learning application for school children to learn hydroponics. Design thinking is a user-centred approach to problem-solving that can be used to develop innovative mobile applications. The design thinking process involves five steps: empathize, define, ideate, prototype, and test. Figure 1 depicts the design thinking workflow applied in creating the hydroponics mobile learning application for children in elementary school in Malaysia.

Figure 2: Design Thinking workflow

Emphatize

During the empathizing process, an integral step is conducting semi-structured interviews to gain a comprehensive understanding of user needs, habits, and concerns regarding learning about hydroponics via mobile applications. In this study, the authors sought to empathize with users and provide suitable solutions by conducting interviews and observations. A total of four users were interviewed, including one teacher from elementary school that teaches a subject with hydroponics topic in the syllabus and four school children that have experiences using m-learning applications, ensuring validation through diverse perspectives. This selection aligns with Nielsen's (2012) recommendation of testing product prototypes with at least three to five users for effective results. By involving actual users (i.e., school children), a well-rounded perspective on the pain points is achieved. The goal of empathize stage is to gather interview outcomes that align with user expectations and interests, as the results are compiled into an affinity diagram for further processing. Ultimately, the empathizing stage determines the criteria for respondents in the project.

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Define

After the empathizing phase, the defining stage comes into play, where the focus shifts towards categorizing the pain points derived from the identified problem. Within this defining stage, the authors employ a method known as How Might We (HMW), to expand the perspective for problem-solving. The HMW method involves transforming statements into questions, as suggested by Rosala (2021). This way enabling authors to pinpoint specific problems and determine the key app features to be prioritized.

Ideate

In the ideate stage, the focus is on generating ideas or solutions that address the previously identified problems. This stage involves intense brainstorming sessions to foster creativity. The ideas collected during this process, which are intended to become app features, are carefully selected, and prioritized based on the perceived impact on users. By envisioning and considering users' needs within each feature, discussions also revolve around crafting a user journey map that visualize the activities, steps, and details users go through in learning hydroponics. The user story map also serves the purpose of finalizing the ideas that will be translated into a design, as it aids users in navigating all the content present within the mobile application. This approach, as suggested by Kaley (2021), ensures a comprehensive and user-centric design process.

Prototyping

Once an idea or solution has been established during the ideate stage, the subsequent phase involves translating the concept into a product prototype. This prototype stage entails the transformation of ideas into tangible representations through the creation of both wireframe/low-fidelity designs and high-fidelity prototypes, as outlined in Pernice (2016). To facilitate the development of these prototypes, this study leverages the Figma software. The low-fidelity design serves as a preliminary sketch depicting the main structure of the app's features, while the high-fidelity design represents the final design with more refined details and visual aesthetics.

Test

The test stage in design thinking is a crucial phase where prototypes and solutions are evaluated to gather feedback and insights from users. The feedback collected during the test stage serves as valuable input for refining and iterating on the design, ultimately leading to an improved and more user-centric final product.

Results and Discussion

Understanding Process: Emphatize and Define

The process of understanding encompasses the empathizing and defining stages, where user problems are analysed to identify crucial considerations from a design standpoint and define desired features. This study builds upon the pain points identified in the perspectives of four users, as depicted in Figure 3. Pain points represent the aspects that users find uncomfortable when going through the process of learning hydroponics. Based on Figure 3, three key areas require focused attention: the information about hydroponics (content), user interface elements, and enhancement activity. Firstly, the information about hydroponics highlights the delivery issues in agriculture education among school children, such as lack of detail explanations, less highlights on crucial steps in hydroponics, and memorable approach to do hydroponics.

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Secondly, the user interface quality emphasizes concerns about a crowded and unattractive design as well as confusing navigation. Lastly, the need for enhancement activities via games draws attention to the fun quality in mobile learning application.

Figure 3: Pain Points (Affinity Diagram)

Based on the identified pain points, this study utilizes the How Might We (HMW) approach to address the categorized pain points that require focused attention. The map of pain points depicted in Figure 3 is discussed with agriculture education experts, resulting in an agreement to prioritize all three key areas: the information about hydroponics, user interface elements, and enhancement activity. This selection aligns with the researchers' goal to enhance the features in existing hydroponic kit (i.e., KIT-Hip, UUM Sintok). To further refine the data, this study incorporates user personas to derive features that cater to the specific needs of users. Table 1 presents the outcomes of the HMW process.

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Table 1: The How Might We Exercise

No.	**Persona:** Elementary school children in Malaysia, age 9 to 12, learn agriculture related topics, and multilingual	
	Pain Points	***How Might We***
1	**Information about hydroponics**	
a.	Users find the explanation about hydroponics (either in textbook or during face to face learning) ineffective	How might we make the explanation about hydroponics more effective to targeted users?
b.	Users often not sure if they follow the steps correctly	How might we make the steps demonstrated effectively?
c.	Users unaware of the best type of plants to grow using hydroponics method	How might we make users informed about the important tips in hydroponics?
d.	Users often unsure about what to observe during the hydroponics process	How might we make users confident they have all the necessary information they need?
e.	Users find information about hydroponics in the textbook too static	How might we make the information more interactive?
2	**User Interface elements**	
a.	Users often require the steps to be repeated when in doubt	How might we make users feel confident they are following the steps correctly?
b.	Users find some hydroponics related application hard to navigate	How might we make the interface navigation intuitive for the users?
c.	Users often find it quite unfulfilling to learn hydropnics without teacher’s explanation	How might we make users feel engaged to the delivery of the content?
d.	Users find some of the UI in hydroponics related application not appealing to young learners	How might we make the UI more age appropriate for the users?
e.	Users find UI with lack of rich multimedia elements boring	How might we create a fun yet educational content for the users?
f.	Users often find existing hydroponics related applications are only available in English	How might we simplify the UI in other language than English?
3	**Assessments**	
a.	Users often disappointed to find no game element in learning hydroponics	How might we make the learning process more fun and exciting
b.	Users find it difficult to remember the poignant part of hydroponics process through monotonous learning	How might we help the users remember the poignant part of hydroponics through fun learning?

Designing Process: Ideate and Prototyping

Once the understanding process is complete, the subsequent stages of ideation and prototyping come into play. During the ideation stage, the user journey is interpreted to determine which features align with users' needs, as illustrated in Figure 4. This journey map serves as a comprehensive guide to uncover the contents of all the feature pages within the hydroponics mobile learning application, enabling users to navigate the app effortlessly. Moreover, this

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journey map simplifies the process of creating app prototypes, streamlining the overall development process (Gibbons, 2018).

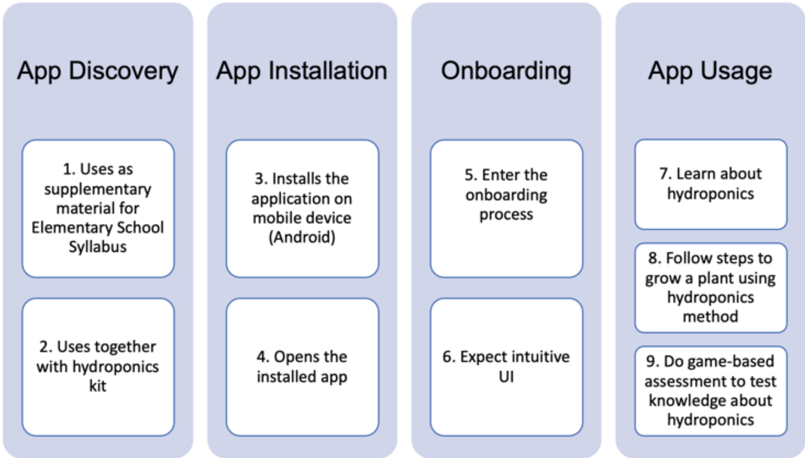

Figure 4: User Journey Map

The low-fidelity prototype (wireframe) represents an initial depiction of the interface design for the forthcoming application. This prototype takes the form of a rough sketch that serves the purpose of determining the required elements of the user interface, as derived from the flow established during the previous journey mapping stage. It also illustrates the interaction between the features and the user. Figure 5 provides a visual representation of the low-fidelity prototype's appearance.

Figure 5: Wireframe (Low Fidelity Prototype)

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Following the completion of the low-fidelity design, the authors proceed to the subsequent stage of creating a high-fidelity prototype. This high-fidelity prototype serves as the final design that will be utilized for user testing, allowing users to engage with and provide feedback on the hydroponics mobile learning application. The application is part of the 12 items in a hydroponics kit, named as Kiddy's Edu Hydroponics Kit.

First, the high-fidelity prototype of the main screen is designed for age-appropriate target users, the theme includes bright coloured graphics and animated 3D avatars. The main screen depicts important information as follows:

a. Logo of the product (i.e., Kiddy's Edu Hydroponics Kit)
b. List of items included in the hydroponics kit to help users identify
c. Introduction of four 3D avatars used in the application to assist users in the content delivery
d. The category of content in the mobile application

Hence, the design enables users to understand the application usage. Additionally, the main screen features a navigation bar, encompassing essential menus in the application, which are: 1) *Kenali Hidroponik* (Learn Hydroponics), 2) *Langkah Hidroponik* (Hydroponics Steps), 3) *Hasil Hidroponik* (Hydroponics Outcome), and 4) *Uji Minda* (Test Your Knowledge). For a visual representation of the high-fidelity main screen prototype, please refer to Figure 6.

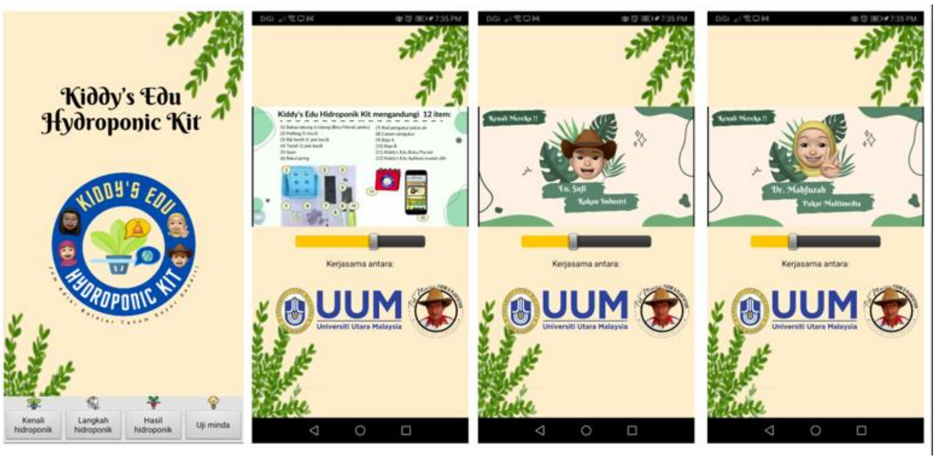

Figure 6: Main Screens (High Fidelity Prototype)

Second, the *Kenali Hidroponik* (Learn Hydroponics) menu is the first menu for users to learn and understand general information about hydroponics including its benefits. The information is delivered through a video that can be played on demand (i.e., users may replay the content as many times as they wish). One of the 3D avatars will play the narrator role throughout the video to give a sense of conversation with the users. For a visual representation of the high-fidelity Learn Hydroponics screen prototypes, please refer to Figure 7.

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Figure 7: Learn Hydroponics Screens (High Fidelity Prototype)

Third, the *Langkah Hidroponik* (Hydroponics Steps) menu includes all the essential steps in growing a plant using hydroponics method. Similarly like the previous menu (i.e., Learn Hydroponics), the steps are explained through a video that can be played on demand. Different 3D avatars are used to act as the narrators, this shows that each avatar has different role based on their expertise. Each step is explained with accompanying visuals (i.e., motion graphics and animations) to provide close-up demonstration that could enhance users understanding. Also, on this screen, sub-menus are added to the existing layer of main menu to help users understand the navigation without confusion. For a visual representation of the high-fidelity Hydroponics Steps screen prototypes, please refer to Figure 8.

Figure 8: "Hydroponics Steps" Screens (High Fidelity Prototype)

Fourth, the *Hasil Hidroponik* (Hydroponics Outcome) menu focuses on the stages that could be observed by the users throughout the hydroponics journey. This information helps to give

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the users more confident in monitoring their plants grow. For a visual representation of the high-fidelity Hydroponics Outcome screen prototypes, please refer to Figure 9.

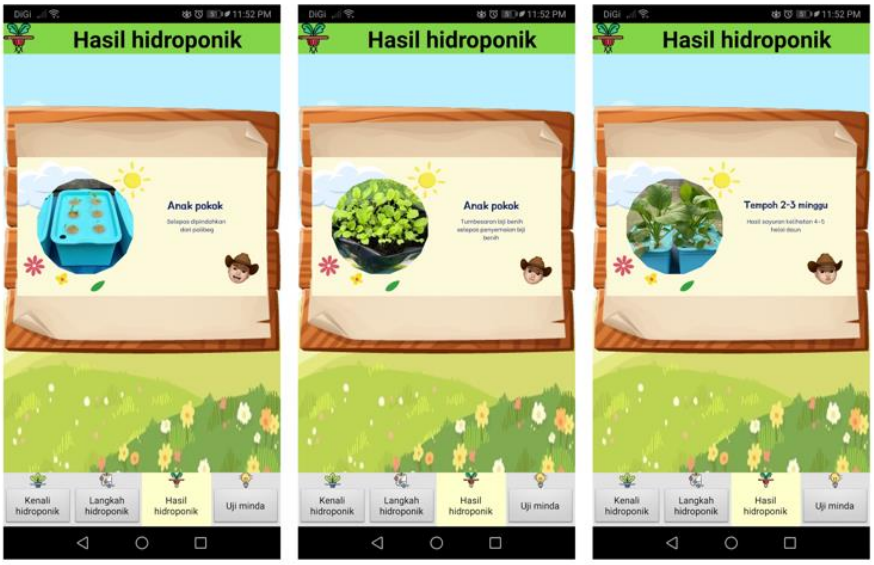

Figure 9: "Hydroponics Outcomes" Screens (High Fidelity Prototype)

Finally, the *Uji Minda* (Test your Knowledge) section includes game-based assessments to test the user's knowledge on what they have learned in the first two sections of the application (i.e., Learn Hydroponics and Hydroponics Steps). For a visual representation of the high-fidelity "Test-your-Knowledge" screen prototypes, please refer to Figure 10.

Figure 10: "Test-your-Knowledge" Screens (High Fidelity Prototype)

Evaluating Process: Test

In this study, the test stage was conducted in a structured and iterative manner. Firstly, a few rounds of formative evaluations that focus on the user interface and functionality of the mobile application were conducted with four experts including the subject matter (i.e., agriculture education) experts. Secondly, a field testing through a survey was carried out which involves 31 primary school children age between 7 and 12. The field testing aimed to provide a validation

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to ensure that the design effectively addresses user needs and delivers a positive user experience. The researchers collated and summarized the feedback on each aspect of the mobile learning application from every iteration. Few improvements were added to the high-fidelity prototype after every iteration in response to the user feedback. Finally, a field usability testing was carried out to measure the overall quality of the mobile learning application. The usability testing managed to compile feedback via Post-Study System Usability Questionnaire (PSSUQ) from 149 school children at several events.

Phase 2: Usability Testing

Method

Participants

A total of 149 school children (n=74, 49.66% girls and n=75, 50.34% boys), participated in this field usability testing. Sample characteristics are presented in Table 2. Participants were recruited from a knowledge transfer program conducted by researchers at participating schools.

Table 2: Demographics Characteristics of Participants

Participants Characteristics	
Gender, n (%)	
Girl	74 (49.66%)
Boy	75 (50.34%)
Age, n (%)	
9	1 (0.67%)
10	3 (2.01%)
11	140 (93.96%)
12	5 (3.36%)
Possess a mobile device, n (%)	
Yes	124 (83.22%)
No	25 (16.78%)
Familiar with hydroponics, n (%)	
Yes	42 (28.19%)
No	107 (71.81%)

Measures: Post-Study System Usability Questionnaire (PSSUQ)

The Post-Study System Usability Questionnaire (PSSUQ) is a well-established and standardized questionnaire consisting of 16 items. It serves as a widely utilized tool to assess users' perceived satisfaction with websites, software, systems, or products upon study completion. Originally developed as part of the IBM project called SUMS (System Usability Metrics) in 1988, the PSSUQ has undergone several iterations, concluding in the current version, PSSUQ Version 3, which is employed in contemporary usability evaluations. PSSUQ has three sub-scales, namely system usefulness (SYSUSE), information quality (INFOQUAL), and interface quality (INTERQUAL). Evaluation via PSSUQ was opted for several reasons: the study wants to know how useful and satisfactory the working flow is, the application dependent on a specific scenario (i.e., hydroponic practice), need to know about the quality of information and overall usefulness more than just the usability of the application.

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PSSUQ Version 3 consists of 16 questions with seven options (including “Not Available” option) to choose from. The list below shows the PSSUQ questionnaire adapted in this study.

1. Overall, I am satisfied with how easy it is to use Kiddy’s Edu Hydroponics App (i.e., the mobile application). (SYSUSE)
2. It was simple to use the mobile application. (SYSUSE)
3. I was able to complete the tasks and scenarios quickly using the mobile application. (SYSUSE)
4. I felt comfortable using the mobile application. (SYSUSE)
5. It was easy to learn to use the mobile application. (SYSUSE)
6. I believe I could become productive quickly using the mobile application. (SYSUSE)
7. The mobile application gave error messages that clearly told me how to fix problems. (INFOQUAL)
8. Whenever I made a mistake using the mobile application, I could recover easily and quickly. (INFOQUAL)
9. The information (such as online help, on-screen messages, and other documentation) provided with this mobile application was clear. (INFOQUAL)
10. It was easy to find the information I needed. (INFOQUAL)
11. The information was effective in helping me complete the tasks and scenarios. (INFOQUAL)
12. The organization of information on the mobile application screens was clear. (INFOQUAL)
13. The interface of the mobile application was pleasant. (INTERQUAL)
14. I liked using the interface of this mobile application. (INTERQUAL)
15. This mobile application has all the functions and capabilities I expect it to have. (INTERQUAL)
16. Overall, I am satisfied with this mobile application. (INTERQUAL)

Procedure

Participants attended group usability testing sessions at their school during knowledge transfer program conducted by the researchers. Each group was provided with a complete set of Kiddy’s Edu Hydroponics Kit including the mobile application. All groups were instructed to perform hydroponics exercise and use the mobile learning application as the guide. They were also asked to think aloud while carrying on the task. Researchers and program volunteers were present to facilitate the sessions and video-record the session for further observation. Then, the participants completed the PSSUQ and a simple survey.

The research team gathered and summarized the feedback on each aspect of the mobile application (i.e., usefulness, information quality and interface quality) from the field usability testing. Then, the mobile application was revised in response to the user feedback. Additional sections and contents were also included in the final product.

Data Analysis

Descriptive statistics were used to analyse the PSSUQ responses. The PSSUQ were measured on a scale ranging from 1 (strongly agree) to 7 (strongly disagree), with lower scores indicating a more favourable user experience compared to higher scores. Even though, failure to complete all items in the questionnaire occurs in this field usability test, it does not invalidate the responses of the available responses into scale scores by averaging across the available items (Lewis, 2002). Norms derived from the original PSSUQ (Sauro & Lewis, 2016) reveals the mean for

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overall rating of 2.82. The 99% confidence interval for the mean overall rating ranged from 2.62 to 3.02. The sub-scale means (along with their respective 99% confidence intervals) were 2.80 (2.57-3.02) for SYSUSE, 3.02 (2.79-3.24) for INFOQUAL, and 2.49 (2.28-2.71) for INTERQUAL. These norms will provide insights into the perceived usability and quality of the Kiddy's Edu Hydroponic mobile learning application.

Results and Discussions

School children had regular access to the mobile applications, and most of them also had regular access to mobile devices (especially smartphone) (Table 2). Most of the school children reported feeling confident with and liking these technologies. Most school children had no experience of performing hydroponics before the evaluation.

The average value for the overall rating was 2.05, meaning that, overall, the participants were satisfied with the mobile application. Indicating a preferable user experience. Meanwhile, the values of system usefulness (SYSUSE), information quality (INFOQUAL), and interface quality (INTERQUAL) can be seen in Table 3 as compared to their corresponding expected norm scores.

Table 3: PSSUQ Average Scores

n = 149	Items	Lower bound	Norm Scores (mean)	Upper bound	Actual Score (mean)
SYSUSE	1 to 6	2.57	**2.80**	3.02	**1.95**
INFOQUAL	7 to 12	2.79	**3.02**	3.24	**2.10**
INTERQUAL	13 to 15	2.28	**2.49**	2.71	**2.22**
Overall	1 to 16	2.62	**2.82**	3.02	**2.05**

The averages across all four measures, including overall usability, were very stable with low variability even though appear to be smaller than the expected norm scores. Again, lower scores indicate more favourable user experience and higher level of usability compared to higher score. The subscale of system usefulness (i.e., SYSUSE) was rated by participants to have the highest usability. Additionally, although only by a small margin, interface quality (i.e., INTERQUAL) was rated the lowest usability. The average score for INFOQUAL appears to receive better ratings than the INTERQUAL, which is not consistent with the normative pattern. The next section will discuss and interpret the patterns found in this study that differ markedly from the observed norms.

The results of the Kiddy's Edu Hydroponic mobile learning application were largely positive indicating that the application is highly usable. However, the participants' responses differ notably from the observed norms derived from the original PSSUQ. Explanation for these differences is discussed in terms of sample characteristics, methodological differences, and contextual factors.

Sample Characteristics

All participants fall within the age range of 9 to 12 years old, indicating that the study specifically targets school children within this age group. It's essential to note that children's usability perceptions may differ from those of adults (Gossen, Höbel, & Nürnberger, 2014) due to their developmental stage and unique cognitive abilities.

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Furthermore, majority of the participants possess a mobile device, indicating that they have access to and are likely familiar with using such technology. It could suggest that they may be comfortable using technology, which could influence their ease of use and understanding of the mobile application.

Methodological Differences

The methodological differences between present evaluation and the methods used to establish the PSSUQ norms are significant. In present evaluation, the task scenario involves using the mobile application in conjunction with hydroponic exercises. This is notably different from the tasks typically used to establish PSSUQ norms. PSSUQ norms are often based on more generic usability scenarios or tasks. The specific context and nature of the tasks can influence participants' perceptions and may lead to differences in usability ratings (Lewis, 2002).

The evaluation took place during a school program aimed at a knowledge transfer of agricultural content, as opposed to a standard usability testing session with controlled protocols, introduces environmental differences. Usability testing sessions typically aim to minimize external influences to maintain consistency. However, a knowledge transfer program like the one conducted for this evaluation has its unique atmosphere, distractions, and dynamics that could affect participants' focus and responses. These environmental variations can lead to differences in perceived usability compared to controlled testing environments (Kallio & Kaikkonen, 2005).

Another critical difference lies in the technology being tested. While the PSSUQ norms may have been established with heavy emphasis on speech dictation systems, present evaluation involves a mobile learning application for hydroponics. Different types of technology can have distinct usability challenges, interface designs, and user expectations. Therefore, it's essential to acknowledge that the technology tested in this study differs significantly from what was used to establish the norms.

Contextual Factors

The study was conducted in a group setting (i.e., 5 to 6 children in a group) where only one mobile device is provided for each group. This limitation is a significant contextual factor, where it can impact participants' interactions with the mobile application. In a group setting, some participants had a more hands-on experience with the device, while others had a more observational role. This disparity in interaction lead to variations in usability perceptions, as those who actively engage with the application may have a different perspective compared to those who do not.

The school's policy prohibiting students from bringing their own devices to school is another important contextual factor. This policy restricts participants' familiarity with their own devices and may influence their comfort level and expertise when using the provided device.

The evaluation was conducted in conjunction with the practice of hydroponics, and the mobile application served as a guide. This context is significant because it introduces a unique motivation for the participants. The excitement and engagement of participants in hands-on hydroponics activities may positively influence their usability perceptions of the mobile application. Participants may be more forgiving of usability issues if they are motivated by the practical learning experience.

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Conclusion

In conclusion, this study aimed to design, develop, and evaluate the usability of the Kiddy's Edu Hydroponic mobile learning application for school children. The objectives were twofold: first, to create an engaging platform for children to learn and practice hydroponics, and second, to assess the usability of the mobile learning application in a real-world field setting.

The results of the PSSUQ evaluation have provided valuable insights into the application's usability. Overall findings were overwhelmingly positive. The feedback and responses from the participating school children indicated that the Kiddy's Edu Hydroponic mobile learning application is highly usable. The enthusiasm and motivation exhibited by the participants during the hydroponics activities suggest that the application not only enhances learning but also contributes to an enjoyable educational experience. Hence, it can be anticipated that the Kiddy's Edu Hydroponic mobile learning application has the potential to make a significant impact in the realm of educational technology. It offers a promising avenue for engaging school children in hands-on learning experiences while promoting the understanding and practice of hydroponics.

While this study has yielded favourable outcomes, the need for continuous improvement and refinement is acknowledged. Future iterations of the application will benefit from the valuable feedback provided by the participants in this study. Further aligning the application with the unique needs and preferences of school children will improve the overall performance of the educational tool.

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