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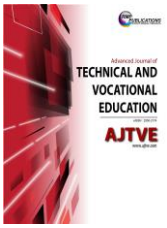

Development of AGRONUTRI-X M-Learning Application using MIT App Inventor 2 Platform

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Abstract: Education today is changing, in line with technology development that has been embedded in our lives. Thus, to meet the needs of today's generation, there is a need to revolutionize conventional instructional methods by integrating technological elements in line with today's advancements. The thriving smartphone technology with high ownership rates needs to be leveraged as a learning medium known as M-learning. Compared to E-learning, M-learning has been deemed a more forward-looking trend in learning as it allows learning to be accessed anytime and anywhere without needing specialized facilities or laboratories. However, the optimal use of M-learning as a learning medium in agricultural TVET has yet to be explored. This gap is demonstrated by the small amount of M-learning materials developed for learning agricultural subjects. This study focuses on developing specific M-learning applications for Crop Agro-industry students in Vocational College, specifically to improve their competency in preparing formulations for fertigation fertilizer. The design and development of the AGRONUTRI-X M-learning application are based on the ADDIE model. The model has five phases in its learning material development process: analysis, design, development, implementation, and testing. Balsamiq Wireframes software was used in designing the storyboard and application interface, and the MIT App Inventor 2 platform was used for the application development using the storyboard and interface provided during the design phase. The application was evaluated by five experts, and the results of the expert content evaluation showed that the application has a high content validity (89.2%). The application was tested on 30 vocational college students during a six-week intervention process which was conducted concurrently with conventional learning. The AGRONUTRI-X M-learning application usability questionnaire was then distributed to these students, and the results showed a high level of application usability with a mean score of 4.41. Overall, the development of AGRONUTRI-X M-learning applications has successfully achieved the objectives and contributed to developing M-learning applications for agriculture students.

Key words: *M-Learning, Mobile Apps, MIT App Inventor 2, Vocational college, Fertigation*

INTRODUCTION

M-learning is not a new phenomenon in education as it has gained traction in tandem with the development of information and communication technology, the advancement of mobile devices, and the provision of fast and easily available internet access. In this regard, M-learning and E-learning are interlinked and are part of digital learning. Implementing digital learning, M-learning, and E-learn methods requires a device and an internet connection [1]. The main differences that can be seen between M-learning and E-learning are in the

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aspects of technological mobilization, user mobilization, and learning mobilization [2]. In the meantime, the 12th Malaysia Plan has outlined the importance of empowering the use of technology and digital learning in the field of TVET in developing future human resources that can contribute to the country's economy. In addition, the Malaysian Education Development Plan (2013-2025) aspires to leverage ICT technology to improve the quality of teaching and learning in Malaysia.

The opportunity to integrate ICT in agricultural TVET should not be missed. In this regard, there is a push to shift from conventional learning to technology-based learning in vocational colleges. This move is especially relevant to cater to today's vocational college students who consist of generation Z. These students are more inclined towards using technology as they are exposed to gadgets since they are young. Undoubtedly, this has influenced how they learn. Thus, teachers should take advantage of students' familiarity and interest in using technology to integrate it into learning [3].

Moreover, according to a report by the Malaysian communication commission 2020, Malaysia is ranked as one of the top 10 countries with the highest smartphone ownership in the world. This shows that it is not impossible to shift the teaching and learning practices in Malaysia towards digital learning through M-learning. Therefore, the M-learning approach should be designed and adapted based on 21st-century learning technologies. MOOC's blended learning approach is seen as an appropriate platform for integrating M-learning as it supports different levels of learning and can be either integrated formally in learning or as an existing learning support tool [4].

M-learning technology has its advantages, allowing learning to take place anywhere, by anyone, and at any time without being tied to the official learning time in the classroom [5]. Student-centered learning with M-learning integration is seen as the best way to increase knowledge and performance as it can provide a space and opportunity for them to explore learning according to time, place, and situation [6].

In this study, the ADDIE teaching design model was used to develop an M-learning application known as AGRONUTRI-X specifically for the competency of preparation of *fertigation formulations (fertigation nutrient mix*) of the Agroindustrial Crop program at the vocational college. The development of the AGRONUTRI-X M-learning application is expected to be integrated into teaching and learning to enhance the understanding of students who attend the course. Thus, this study examines the development of the AGRONUTRI-X M-learning application.

PROBLEM STATEMENT

The research problem was highlighted by a survey involving Sijil Vokasional Malaysia (SVM) graduates from vocational colleges. During the survey, the respondents were asked questions about competencies they face difficulties mastering while studying for their SVM. The study's initial findings found that the respondents perceived that the most difficult competency to master is the preparation of fertigation fertilizer formulations. This is supported by the 2021continuous assessment performance report of SVM students enrolled in the Crop Agroindustrial program at Teluk Intan Vocational College. The report showed many students had low achievement and competency in preparing fertigation fertilizer formulations. Students' low achievement and perception that this aspect is difficult are due to their inability to recognize different types of chemicals and failure to understand the basic principles of fertilizers preparation [7].

The questionnaire survey also asked the respondents to recommend the learning materials that teachers should develop to assist them in obtaining high competencies at the SVM level. 58.3% of respondents recommended developing smartphone applications that can be used as learning materials to assist in learning complex and challenging topics.

Conventional delivery methods have been unsuccessful in facilitating 21st-century teaching and learning approaches that are student-centered, skill-focused, and accessible at any time and not limited to the classroom alone [8]. This is evident in vocational colleges where learning relies entirely on written materials. In this light theoretical components are delivered using chalk and talk, while demonstrations or simulations are used for teaching practical components.

Based on the above statement, improving existing teaching and learning methods will be improved by developing an M-learning application that includes technological elements such as graphics, text, videos, and quizzes that are loaded into an application. Past studies on M-learning use have shown a positive effect on performance, motivation, attitudes, and consumer satisfaction. M-learning applications need to be explored to leverage technology and give students the space to explore learning more interestingly [9]. The development of this M-learning application focused on addressing the problems raised and creating awareness among teachers about using M-learning to improve student performance and interest.

OBJECTIVE

This study aims to develop a mobile application for android-type devices based on the concept of blended learning for the competency of preparation of fertigation fertilizer formulations in the Agro-industry

Crop program at the vocational college. The main content of the application is based on the Vocational College Standard Curriculum (KSKV) at the Malaysian Vocational Certificate (SVM) level

LITERATURE REVIEW

The rapid pace of technological change has driven the education field to shift from pen and paper-based learning materials and printed materials to technology-based learning materials. Learning is also not limited only to the classroom alone. The development of the use of technology in the world of education is also driven by current studies that show its advantages. Today, smartphones are widely leveraged as educational intermediaries due to their diverse ability and functionality.

M-pembelajaran

The main emphasis of M-learning is the mobilization of learning, allowing learning to take place anywhere without needing expensive hardware, facilities, and specialized infrastructures. M-learning is evolving in tandem with the advancement of smartphones. Nowadays, smartphones cannot only access the internet, but some can perform the same functions as personal computers [10]. The main advantage of M-learning is the ownership of the device. In this case, M-learning only requires smart devices like smartphones owned by most individuals. Hence, they are not reliant on devices provided by their respective educational institutions. In this regard, learning is not limited to classroom learning sessions, and the students can explore knowledge independently [5]. However, with the sophistication of M-learning, a more distant relationship between teachers and pupils is likely to occur due to the lack of interaction between teachers and pupils, and teachers' role in motivating students will decrease. Blaschke & Hase [6] argued that this is not a big problem in implementing M-learning. This is because, in the heutagogy approach, the teacher will act as a facilitator to provide space and autonomy to students in exploring self-learning using the available information resources.

An observation by Yıldız et al. [11], between 2016-2019, found that only 1.34% of M-learning applications developed are for learning agriculture. This suggests the lack of M-learning-based agricultural apps as learning materials. In addition, applications in agriculture available through Google Play are more focused on market info, farm management, disease or pest management, and precision farming [12]. There is also no specific application for the preparation of fertigation fertilizer formulations available on Google Play, except for nutrient calculation and nutrient distribution tables. Therefore, the development of M-learning applications in this topic is necessary to give users the option to study this topic and further extend the use of M-learning in agriculture.

MIT App Inventor 2

The AgroNUTRI-X M-learning application is developed based on the MIT App Inventor 2 platform; an integrated online development application operated by the Massachusetts Institute of Technology (MIT). The platform allows novice developers who are less skilled in programming to develop android-type smartphone applications in a complex programming language [13]. According to Patton et al. [14], available command blocks that can be combined according to the user's creativity and ability to convert application files into .apk and .aab formats are key to why this platform is the choice of novice application developers. Since 73% of the world market is android-type smartphones, developing the AGRONUTRI-X M-learning application using the MIT App Inventor 2 platform is something that deserves to be done.

Blended learning in TVET

Blended learning in TVET entails learning based on knowledge, skills, and softness acquired through face-to-face learning and technology so that students can gain practical experience. [15]. Rossett et al. [16] explained that blended learning strategies could combine several technologies or elements of technology-based learning materials such as video, animation, websites, and so on with the times. The use of M-learning in blended learning fulfills these characteristics due to its ability to combine multiple elements in a single application [17]. The best strategy for integrating M-learning into blended learning is by integrating MOOC (Massive Open Online Courses), which can be accessed using a smartphone. This will make it easier for users to get information locally without multiple searches [4] [18].

Learning Theories

This M-learning application integrates several learning theories in the design and development process. These theories include the dual coding theory introduced by Paivio [19]. This theory is an extension of the theory of cognitivism. This theory enhances memory storage by using two senses simultaneously, the visual and verbal channels. This is supported by Mayer [20], who related it to the use of multimedia as learning material. According to him, the mind will store texts in verbal memory and images in visual memory, thus coordinating the image in the visual memory and linking it to the existing experience or knowledge. In addition, using multimedia as a learning material will help reduce the cognitive burden and help construct knowledge according to the theory of constructivism. Cognitive theory and constructivism are intertwined in forming knowledge. In this light, using different senses is linked

to the surrounding experiences, thus building meaning to form new knowledge.

The theory of behaviorism is a change in behavior due to the constant training and exposure received by a person [21]. A great example of this is the use of positive reinforcement to shape behavior change. Here, praise or reward will encourage students to learn and practice new behavior. Rachlin [22] explained that positive reinforcement in modern learning would encourage repetition by students, stimulate the mind, and reduce stress. This can be done through quizzes or questions provided in the app.

Shifting from the theory of constructivism and behaviorism, the contextual theory that focuses on applying learning content that can be applied to the real world was introduced [23]. Mayer [24] explained that new knowledge is easier to build if learning is done by associating it with everyday life or showing how it can be used practically. Contextual theory in M-learning applications can be applied to practical exercises to support face-to-face learning through multimedia, video, virtual reality, augmented reality, and others [25].

The AGRONUTRI-X M-learning application combines cognitivism, constructivism, behaviorism, and contextualism theories. In addition to the theory of multimedia learning, cognitive overload is considered when designing storyboards and application interfaces. Moreover, the development process followed the ADDIE model guide.

RESEARCH DESIGN

AGRONUTRI-X M-learning application was developed using the ADDIE design model to ensure that the development process runs in an orderly and directed manner. The ADDIE model is often used as a reference for the development of Training modules, teaching aids, and multimedia materials. The model has a structured working phase that guides the design and development of teaching materials. In addition, the flexibility of the ADDIE model also makes it easy to implement. While each phase and sub-phase serves as a guide, it is not compulsory for designers to implement every phase [26].

Figure 1 illustrates the development flow of AGRONUTRI-X M-learning applications based on the ADDIE model

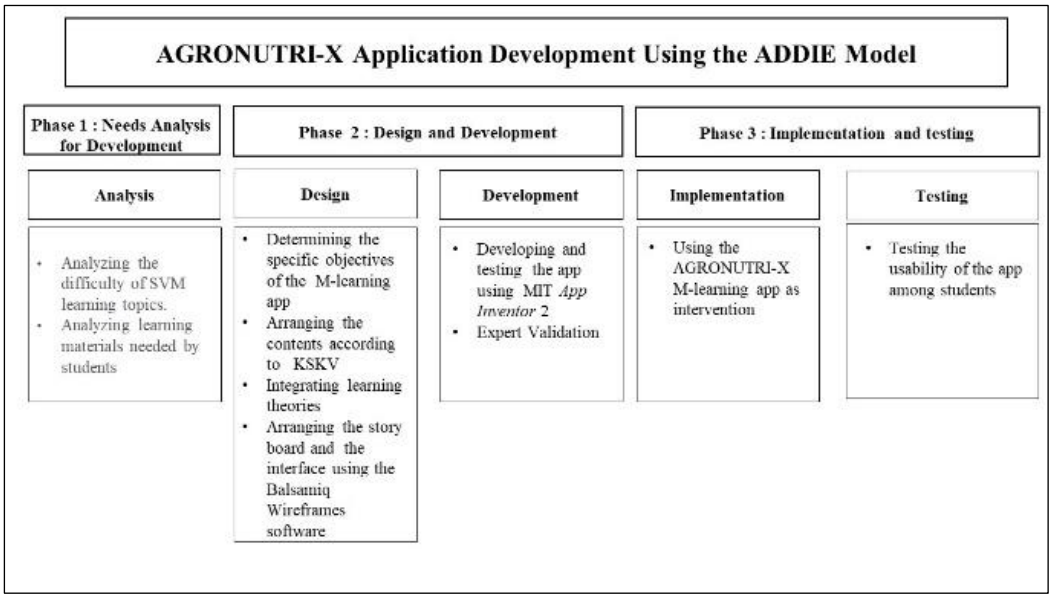

Fig 1 development process based on the ADDIE model

Analysis

The application development process begins with an analysis phase in which the researchers conducted a needs analysis study to identify the scenarios and the target group's needs. For this purpose, a survey of the difficulty analysis of learning topics at the SVM study level is carried out with an analysis of the type of multimedia material students want in studying this considered difficult topic. The competency difficulty analysis was carried out on 236 SVM graduates of the Crop Agro-industry program at vocational colleges throughout Malaysia, as a result of the questionnaire survey found that the competency of preparing fertigation fertilizer formulations is a competence that is considered difficult for them. As explained in the problem statement, most respondents suggested that

teachers/instructors develop learning materials to help them learn difficult components through M-learning applications. After identifying the user's needs, the M-learning application design process is continued based on objectives, strategies, and approaches, the application of learning theories, the compilation of the content, and the presentation of the interface.

Design

Before the application was developed using the MIT App Inventor 2 platform, the storyboard design, and interface display were designed using the Balsamiq Wireframes software. The software facilitates the development process as all the features of the required final product elements can be incorporated into the software [27].

The research arranged the contents first since the MIT Inventor 2 platform limits only 10 screens for application development [14]. The researchers combined six content standards in the curriculum into four main topics. This approach is important to reduce the cognitive burden as users perceive many texts in a topic as more difficult to read and understand than fewer topics. [28].

In this phase, all learning theories, including dual coding, were applied to the storyboard using graphics to help users understand complex information that might be difficult to explain using texts [19]. The lesson content can be applied to the real world through contextual learning theory. It is applied in this M-learning application by using videos that show how skills and information are applied in the situations in the agricultural TVET field. Furthermore, positive reinforcement under the theory of behaviorism was applied in the quiz items to increase users' motivation and enjoyment. Strategies and approaches of M-learning used in this application can facilitate blended learning. Users can directly construct knowledge based on what they feel and hear and link it to real-world situations to make meaning and subsequently form new knowledge [29]. At the same, the application interface only displays the information that the user wants to avoid distracting the users with buttons and programming settings.

Fig 2 Application Interface Design

Development

AgroNUTRI-X M-learning application development involved developing the application using the MIT App Inventor 2, checking the validity of the application content, and publishing the application in the Google Play Store. The storyboard was constructed using Balsamiq Wireframes software with the desired functions. It was then translated to development using the MIT App Inventor 2 platform. MIT App Inventor 2 is a free android-type mobile application development platform operated by the Massachusetts Institute of Technology (MIT). The platform does not require complex programming and uses only available command blocks [30]. The concept of "What you see is what you get" of the MIT App Inventor 2 has greatly helped the application development process. It allows application testing to be carried out from time to time without waiting for the application to be fully completed. The application display, instructions, and functionality were tested via USB, AI companion, or emulator. In this regard, the MIT app inventor is advantageous due to its ability to convert files built into .apk file formats that can be installed directly into a smartphone and .aab format to upload to Google Play Store.

Application developers must provide two main parts on MIT App Inventor 2 screens, the components, and the command block. The components on the screen are the command buttons, decorations, and settings. On the other hand, the command block represents the programming to allow the command buttons and settings to work as required by the application

developer. Nine screens were used to develop this AGRONUTRI-X M-learning application. These screens are user login, main menu, fertigation fertilizer, fertigation fertilizer quiz, plant nutrients, plant nutrient quiz, chemical fertilizer, chemical fertilizer quiz, and fertilizer formulation. The researchers used three self-recorded videos as multimedia material in this M-learning application. All three videos were inserted into The application via a link to the YouTube site through the button function and the MIT App Inventor 2 command. The completed application was tested to see its usability before being given to experts for content validity evaluation. The application is in the .apk format so that it can be installed on a smartphone and tested by experts.

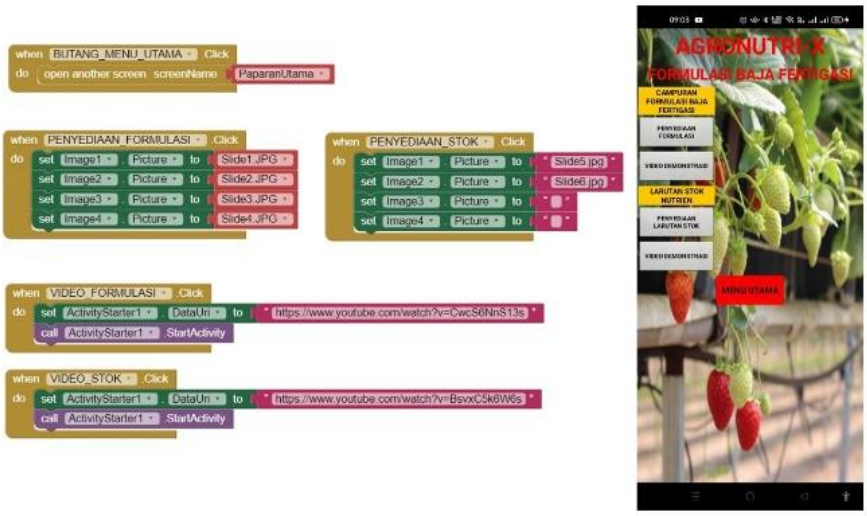

Fig 3 Application development using MIT App Inventor 2

Fig 4 Video link to Youtube

Five experts were appointed as reviewers to evaluate the validity of the application's contents. They comprised three experts in the field of agricultural TVET who are teaching in vocational colleges and two experts in the field of mobile application development. The expert evaluation of the content validity of the AGRONUTRI-X M-learning application was based on five aspects, i.e., meeting the needs of the target population, it can be implemented seamlessly, adequate time allocation, ability to improve student performance, and the application's ability to change students' attitudes toward excellence [31]. The validity of the content was evaluated based on five questionnaire items using a 10-point Likert scale (ranging from strongly disagree [1] to strongly agree [10]). Each item and the whole questionnaire should score 70% or higher during the

evaluation to ensure good content validity [32]. The results of the expert assessment showed that the AGRONUTRI-X M-learning application has a good level of content validity with an overall content validity percentage of 89.2%.

Table 1: Experts' Evaluation of the Content Validity

AGRONUTRI-X App Content Evaluation Aspects	Percentage (%)
1. The content of the AGRONUTRI-X M-learning app for Crop Agro-industry SVM students in Vocational College **meet the needs of the target population.**	92
2. The content of the AGRONUTRI-X M-learning app for Crop Agro-industry SVM students in Vocational College can be implemented **seamlessly.**	88
3. The content of the AGRONUTRI-X M-learning app for Crop Agro-industry SVM students in Vocational College **suit the time allocation**.	88
4. The content of the AGRONUTRI-X M-learning app for Crop Agro-industry SVM students in Vocational College **can increase students' academic achievement**	90
5. The content of the AGRONUTRI-X M-learning app for Crop Agro-industry SVM students in Vocational College can change students' attitude toward excellence.	88
Overall Content validity	**89.2**

Implementation and Testing

The application's usability was tested on 30 vocational college students involving a six-week application implementation period. The application was applied in teaching through blended learning, i.e., by maintaining the existing conventional learning materials using written learning materials (WIM) and integrating AGRONUTRI-X M-learning applications as supporting learning materials and guided learning materials while conducting practical activities. The researchers used a questionnaire to determine the respondents' perception of the instrument's usability after the end of the intervention period. Measuring the usability of the AGRONUTRI-X M-learning application is a necessary step to assess the advantages, disadvantages, feasibility of applications in real situations, and the application's ability to achieve the set objectives. The questionnaire contains 10 items to assess the usability level of AGRONUTRI-X M-learning applications which were adapted from the study by [33]. The questionnaire uses a five-point Likert scale to represent the respondents' agreement with the application's usability statements. The scale ranges from 1=Strongly disagree, 2=Disagree, 3=Somewhat Disagree, 4=Agree, and 5=Strongly Agree. The findings of the usability survey were analyzed statistically descriptively and performed an interpretation of the mean score as recommended by Pallant [34] to reflect the usability level of AGRONUTRI-X M-learning applications at low, medium, or high levels.

Table 2: Interpretation of mean score

Mean Scale	Mean Level Interpretation
3.34 – 5.00	High
1.67 – 3.33	Average
0.00 – 1.66	Low

Source: adapted from Pallant (2002)

The analysis of data from the questionnaire distributed among Crop Agro-industry students in the vocational college showed that the agroNUTRI-X M-learning application has a high level of usability, with an overall mean value of 4.41. These findings show that The application developed received not only positive feedback from experts but also good feedback from the target group. Therefore, the AGRONUTRI-X M-learning application can be integrated into learning in vocational colleges.

Table 3: Interpretation of mean score

No.	Item	Percentage (%)					Mean	Interpretation
		SD	D	SWA	S	SS		
S1	This App is user friendly				83.3 (25)	16.7 (5)	4.17	High
S2	Learning using this app is fun.			3.3 (1)	90 (27)	6.7 (2)	4.03	High
S3	Information is presented in a simple and attractive style			3.3 (1)	80 (24)	16.7 (5)	4.13	High
S4	This application reinforces the user's existing knowledge				50 (15)	50 (15)	4.50	High
S5	This application is related to learning in a vocational college				6.7 (2)	93.3 (28)	4.93	High
S6	This application can be applied in everyday life			6.7 (2)	80 (24)	13.3 (4)	4.07	High
S7	This application provides the necessary knowledge quickly				70 (21)	30 (9)	4.30	High
S8	This application is suitable for use as a learning material				26.7 (8)	73.3 (22)	4.73	High
S9	The information provided is clear and concise				50 (15)	50 (15)	4.50	High
S10	This application improves user skills on fertigation fertilizer formulation preparation				30 (9)	70 (21)	4.70	High
	Mean						**4.41**	**High**

Application Publishing

Apart from the use of .apk format files to install applications into smartphones, applications developed using MIT App Inventor 2 can also be published in the Google Play Store. The MIT App Inventor 2 platform allows the .aab format files required to upload The application to Google Play Console to be created by selecting and using the available commands. Before the files were uploaded files for publishing, the researchers were required to open an account on Google Play Console and make a payment of USD 25. The registered account owner only needs to make a one-time payment and can upload as many apps to Google Play Console. Moreover, before The application files in .aab format can be uploaded, The application developer needs to fill in the information and make a certificate of compliance with the rules set by Google. The "Roll Out to Production" process would start after the files were uploaded to the Google Play Console site. At this stage, the Google administrators will examine the application's content and check for regulatory compliance before the application can be published on the Google Play Store. This process usually takes three days.

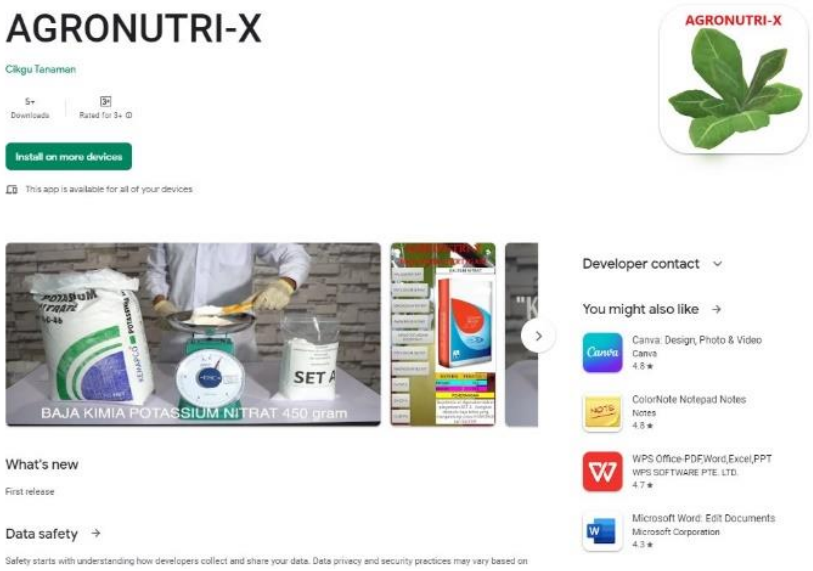

Fig 5 Publishing the application on the Google Play Store

CONCLUSION

In conclusion, this paper reported the development of the AGRONUTRI-X M-learning, including the application usability evaluation phase based on the users' perspectives. The development of this application aims to solve students' problems and cater to the learning needs of today's students who demand technologically minded learning materials. This application serves as a learning support material for students in enhancing understanding and skills for the competency of preparation of fertigation fertilizer formulations. Past studies have shown that the design and development of an application grounded on learning and multimedia theories can positively affect its users, specifically students. The next phase will be testing the AGRONUTRI-X M-learning application's effectiveness on the target group.

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