International Journal of Innovation in Enterprise System, Volume 3, Issue 01 June 2019, pp 64-70

Augmented Reality-Based Mobile Application for Knowledge Transferring in The System of Rice Intensification

Phuripoj Kaewyong[1] and Shatchaya Duangchant[2*]

[1,2]Suan Dusit University, Thailand,

phuripoj@yahoo.com[1], shachaya@gmail.com[2]

Corresponding author: shachaya@gmail.com
Received: 13 September 2018, Accepted: 16 January 2019, Published: 13 July 2019

***Abstract*—**Currently, the System of Rice Intensification (SRI) is one method that can be applied and used to produce seeds of local rice species in highland areas. However, it can currently be seen that the traditional methods to transfer knowledge about SRI from the experts still have limitations in many aspects due to the number of farmers that have experienced success still being low. Some farmers do not have their own fields and it takes a period for farmers to test the rice growing. Currently, mobile devices are widely used in peoples' lives. Many scholars focus on the application of mobile devices and the augmented reality (AR) technology for the simulation games in many issues while the use of AR-based mobile applications as the learning tools is not widespread. There-fore, in this study, we propose the development of an application on mobile devices with augmented reality technology in order to use it as media in sharing knowledge related to the methods of the System of Rice Intensification by virtual farms simulation. To examine the efficiency of this developed application. A total amount of participants were 512 farmers from 5 regions of Thailand. The experimental results demonstrated that the newly developed AR-based mobile application is effective for improved knowledge on the participants who used the developed application and it can help them to practice their SRI farming skill in the virtual farm simulation. This indicates that the developed AR-based mobile application is the benefits tool for the new knowledge transferring meth-od in the system of rice intensification. For future work, it is necessary to evaluate the farmer success after learning from this AR-based mobile application in order to study the impact of the new method of SRI knowledge transferring.

***Keywords*—**augmented reality, knowledge transferring, system of rice intensification.

I. INTRODUCTION

Currently, exports of rice grown in Thailand are ranked 6th in the world, and Thailand is a major rice growing location that produces for the international markets. Furthermore, the country is also a center of research studies of many species and many types of rice. High-land communities have knowledge of growing many various species due to each community having more than one species of rice. Farmers popularly grow at least two species of rice per season, either on adjoining plots of land or with many species of rice growing on a single plot of land, which is a method that helps reduce the risks resulting from variations in weather conditions. However, rice growing with a large variety of species that continues for a long time without having an effective method to select and collect the seeds of species will result in mixed and mutated species of rice.

The System of Rice Intensification is one method that can be applied and used for pro-duction of seeds of local rice species in highland areas that are pure in accordance with species in order to reduce mixing of species of rice [1]. The System of Rice Intensification is rice growing by using young rice seedlings spaced far apart and situated with the management of water being dry, then wet during the period of growth, as well as using organic matter for improvement of the physical characteristics of the soil. The strengths of the System of Rice Intensification, namely reduction of capital for production and reduction of the amount of water that is used in the fields, increase production in the rice fields [2].

A problem that occurs in the encouragement of farmers to start implementing the System of Rice Intensification is changing their opinion and spreading the knowledge among farmers. Currently, popular encouragement of farmers who are interested to study together in groups about the rice growing of farms that have experienced success. Following this, they can conduct test planting on small plots in their own fields and when successful, the growing areas will be expanded. Subsequently, members in the community network that have experienced success will be the people to provide knowledge and disseminate the method as well as be the experts who can provide ongoing advice to other members of the community. Therefore, the success or failure of the encouragement of the System of Rice Intensification to farmers depends on the operations of com-munities in the transferring of this knowledge to farmers [2].

However, it can currently be seen that the methods to transfer knowledge about the System of Rice

Intensification still have limitations in many aspects due to the number of farmers that have experienced success still being low. Some farmers do not have their own fields and it takes a period for farmers to test rice growing with the abovementioned method for success in test plots before expanding the results until changing to the actual fields. Therefore, the application of new innovations to help with the transfer of knowledge by allowing farmers to be able to learn from simulated situations to test rice intensification in order to help reduce the limitations of period and capital in test areas must be a necessity.

Currently, augmented reality technology is the technology that is a combination be-tween reality and a virtual world that can be merged together in various media formats such as graphic images, videos, three-dimensional shapes and written materials superimposed with images of the real world that are displayed on the camera and leads to the possibility of creating the simulated situations within the format of an application that is attractive, interesting and easy to use in order to encourage learning all of the time and be accessible on everyone's mobile devices. Therefore, development of an application on mobile devices with augmented reality technology in order to use it as media in sharing knowledge related to the methods of the System of Rice Intensification by virtual simulation of the situations. The characteristics of the three-dimensional media will be able to help reduce the various limitations mentioned above and serve as the place to learn with groups of people who are interested in the System of Rice Intensification nationwide. As a result of the use of this application as the media that helps encourage knowledge and will be able to lead to enhancement of the quality of life of Thai people by providing continuous learning any place at any time.

II. LITERATURE REVIEW

In this study on an augmented reality-based mobile application for knowledge transfer in a system of rice intensification, the researchers conducted a review of the literature and interviewed related experts in order to compile the relevant theories and research work the details of which can be summarized as follows.

2.1.System of Rice Intensification

Based on the review of the literature and the interviews with experts, it was found that the System of Rice Intensification involves rice growing by using young rice seedlings spaced far apart with the water management alternating between wet and dry during the period of growth, as well as using organic matter for the improvement of the physical characteristics of the soil, that is divided into four periods [3] as follows:

Stage 1: The period of seedlings is when there is sprouting and growth of the plants and root. This period lasts 0-30 days by dividing the control of the water into three periods, and in this period, the seedlings will have their smallest size.

Stage 2: The period of tillering is when the seedlings have increased sprouting and the roots have started branching that expands beyond that of the seedling period.

Stage 3: The period of booting is when the rice starts to have a growing and developing a panicle and its constituent parts are completed inside the sheath of the flag leaf. In this period, it will change from plants that have flat characteristics to round plants and the small flowers of the rice will expand and grow larger until becoming a complete cluster.

Stage 4: The period of milky and mature rice is when the rice has strong growth of the ears of rice grains. The rice plants begin to change from dark green to light green and then become yellow. This is the period that food received from photosynthesis will be accumulated in the grains arranged in many locations. Thus, this period is also called the period of accumulation in the grains.

2.2.The Traditional Knowledge Transfer in the System of Rice Intensification

Promotion of the System of Rice Intensification for farmers will lead to its use, the success or failure of which will depend on the performance of the community in the transfer of knowledge to farmers using various methods to share knowledge in order to encourage them to start the System of Rice Intensification at present. This encouragement of farmers who are interested together in groups and studying the results from the rice growing plots of farms that have experienced success can be followed by test planting in small plots of land in their own fields. When they have achieved success, they will expand the areas for growing. Following this, members in community network that are successful will be the persons to provide knowledge and disseminate the methods as well as be experts that offer ongoing recommendations to other members in the community [2]. However, based on the interviews with the concerned workers and experts in agriculture, it was found that the current methods to transfer knowledge still have limitations in many aspects resulting from the number of prototype farmers that have experienced success still being low. Moreover, some farmers do not have fields of their own and a large amount of time is required for testing of rice growing in test plots to facilitate success before followed by expansion of the production until changing to their actual fields. Therefore, an application with new innovations will

help in the transfer of knowledge by allowing farmers to be able to learn from simulated situations to test rice intensification in order to help overcome limitations in the aspects of test plots, the period of time, the capital, and the workers that will share knowledge with farmers, which are necessities.

2.3.Augmented reality (AR)

Augmented reality technology is a type of technology that merges the world of reality with a virtual world through devices, cameras, computers, and various software, which results in the meshing of a simulation with the actual location and time in order to show the results through devices such as screens of mobile devices, smart phones, and computers [4], [5], [6].

From the related studies and research work, it was found that currently, there are re-searchers applying AR technology for use in many purposes such as [7], who applied AR technology for use in conjunction with QR code in order to access many user groups; however, the majority of users are still unfamiliar with the technology of augmented reality, which made it inconvenient when entering requires downloading the program for scanning QR code before using the service, which is different from using QR code through the LINE application. Meanwhile, [8] had an application with AR technology used in the field of business by designing connections for users that are appropriate for increasing numbers of users and has a display to show the results in a smartware format that users can easily use. In addition, in the study of [9] there was use of an application with augmented reality technology applied in aspects of ecology by the simulation of the sensory sensations with an algorithm based on theoretical assumptions regarding the nervous system. In addition, [10] applied the technology mentioned to the development of googles with a web browser. Moreover, in the study of [5] the augmented reality technology was used as a tool for sharing knowledge in flipped classrooms and it was found that it is a tool that has good levels of efficiency. In the same direction, in the study of [4], [11], [12], [13] they applied the augmented reality technology as a learning tool for sharing knowledge for the education. In addition to another scholar try to study AR technology's design elements for transfer the information to the tourism, such as in the study of [6], they study the factors for knowledge transfer in mobile game base city tours on smartphones. They proposed a mobile game-based city tour application on the iPhone in order to present historical information and legends about the German city Ratisbon for the tourists. While in the study of [14] they study the role of augmented reality in enhancing museum experiences and purchase intentions. The idea of this study is to examine the effects of AR technology's design elements on visitors' museum experiences and purchasing intentions. Moreover, in the study of [15], they proposed an RFID-based approach for recognition of multiple tagged objects in augmented reality systems. It can effectively recognize multiple objects with different visual characteristics such as recognize different human subjects in the cafe and recognize different cultural relics in the museum.

From the research work mentioned above, it was found that development of augmented reality involves technology that is a combination between reality and virtual worlds together through software and various interconnected devices by being able to show the images including still images, moving images and three-dimensional images in many various formats and users have good levels of satisfaction with AR technology. Therefore, there is a possibility that this type of technology can be used to develop the application program on mobile devices for transferring knowledge about the System of Rice Intensification in order to solve the problems with the traditional methods of knowledge sharing.

2.4.An augmented reality-based mobile application for knowledge transfer in the system of rice intensification

In this study, the application program on mobile devices that involves the System of Rice Intensification was designed and developed in order to be used as the media to simulate virtual situations in sharing knowledge about the System of Rice Intensification with the persons who are interested by using AR technology in a three-dimensional format that can overcome the various limitations mentioned above that hinder sharing knowledge in the traditional methods, as shown in Fig. 1.

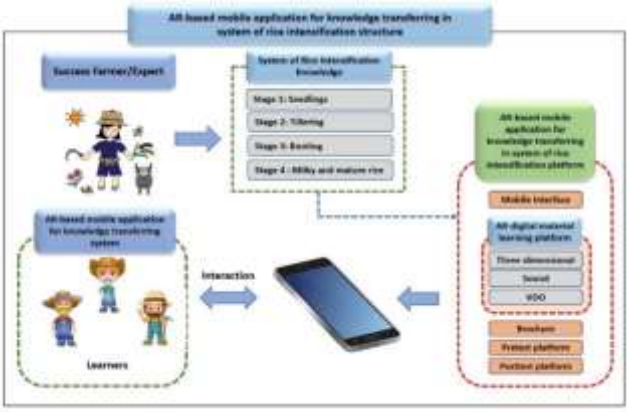

Fig. 1 The structure of an augmented reality-based mobile application for knowledge transfer in the system of rice intensification

III. EXPERIMENT DESIGN

In this part, the steps of conducting this study in the

design and development of the mobile application in order to share knowledge about the System of Rice Intensification with augmented reality technology, study the efficiency of application, and study the satisfaction that the users that have with the application that has been developed. Thus, the steps of the methods of conducting this research will be explained.

3.1.Participants

The participants included people who are interested in the System of Rice Intensification nationwide.

The sample groups included:

i. the sample group used in the testing of original system, the amount of which was 30 people.
ii. the sample group used in the research included a total amount of 500 people, namely farmers and persons that are interested in the System of Rice Intensification. These were divided by the five regions of Thailand into areas rice growing based on the statistics of the [16] which are the northern region, central region, the eastern region, the northeastern region and the southern region with approximately 100 people per region.

3.2.The Instruments

The instruments used in this research include:

i. The interview questionnaires regarding the needs and the content that will be used in the development application with augmented reality technology involving the System of Rice Intensification in a three-dimensional format by an open-ended questionnaires in order to ask for the information about the design of the screen and information on the System of Rice Intensification that will be presented in the application that will be developed.
ii. A 4-point test in order to examine the efficiency of the augmented reality application on mobile devices in order to transfer knowledge about the System of Rice Intensification divided into pretest before the trial of the media that created 10 items and posttest after the trial of the media that created 10 items resulting in a total of 20 items for testing the results of the learning achievements of the sample group using the Effectiveness Index (EI) by setting the criteria of the Effectiveness Index that should have a value from 0.50 and up to indicate that the innovations have the effectiveness [18].

3.3.Experimental process

Step 1: Determination of the aims and objectives - The researchers determined the aims and objectives in order to develop the application with augmented reality technology about the System of Rice Intensification in a three-dimensional format.

Step 2: Examination of the technology - The researchers examined the technology that are appropriate for devices in the current actual conditions and the actual conditions of the areas that the media is used for testing in order to provide devices that are appropriate and will lead to using the prototype media in the development of learning packages.

Step 3: Data collection and analysis of information - The survey of the information regarding the content of the System of Rice Intensification with the interviews and the content from three experts in agriculture and will lead to the design of the content in order to create the storyboards with the design of the content and descriptions in building the three-dimensional model, which is able to rotate and zoom in on each image for a close-up views in order to see the composition of the rice plants. Then, this will be given to the experts to evaluate the correctness and accuracy of the content.

Step 4: Character design - The content that came from the third step was used in the design of the materials in the enhancement of the three-dimensional model.

Step 5: User interface design - The design of the user interface was done for each screen in order to add the information by arranging it in accordance with the storyboards that were designed in the third step. When users enter each menu, it will display the con-tent of the System of Rice Intensification in each period by using AR technology in a three-dimensional format that will show the results when users record images with the tele-phone from the chart on which the System of Rice Intensification has created markers.

Step 6: Creation of the media - When the researchers conducted the modification of the content and trial and storyboards are completely ready, it was returned to the experts to inspect again. After that, the researchers conducted the survey of the site that examined information regarding customs that determine the important days that are within the time period of the research, so as to determine the period of time in the filming as well as conduct the filming according to the storyboards, conduct the editing and record the sound according to the storyboards that were designed.

Step 7: Testing of the developed application - After conducting the development of the original application was completely finished, it was tried out with the sample group of 30 people in order to test and to review the understanding of the meanings of the prototype application that was improved and given to the three experts in the production of learning media to evaluate the suitability of the content that was designed

for the storyboards, the content that is presented in the media, the components of media and the suitability of the context for the areas. The experts in the production of the media had the opinion that the original application that was developed has the suitability is in line with the content and objectives of the research.

Step 8: The testing of the transfer of knowledge by using the new developed application - After improving the original application according to the items recommended by the experts and the solving of the problems that were met in the first sample group, the application that was developed was tested for use in transfer of knowledge with the sample group, namely farmers and persons that are interested in the System of Rice Intensification divided according to the five regions of Thailand by division into rice growing areas from the statistics of the [16], namely the northern region, central region, the eastern region, the northeast-ern region, and the southern region with approximately 100 people per region.

Step 9: Evaluation of the results - This step evaluated the knowledge of the mobile application users and was divided into two parts, which were evaluation of the knowledge before using the developed application and evaluation of the knowledge after using the developed application. Moreover, the results of these two parts led to the evaluation of the learning achievements results of the sample group in terms of both the evaluation of the efficiency and the satisfaction of the users with the augmented reality-based mobile application that has been developed, as shown in Fig. 2.

Step 10: Distribution of the mobile application – After the testing of the application with augmented reality technology that was developed. The researchers created the mobile application package that was developed in each region, then delivered to the community learning locations and educational agencies in those regions. In addition, there was dissemination of the content through the youtube.com website.

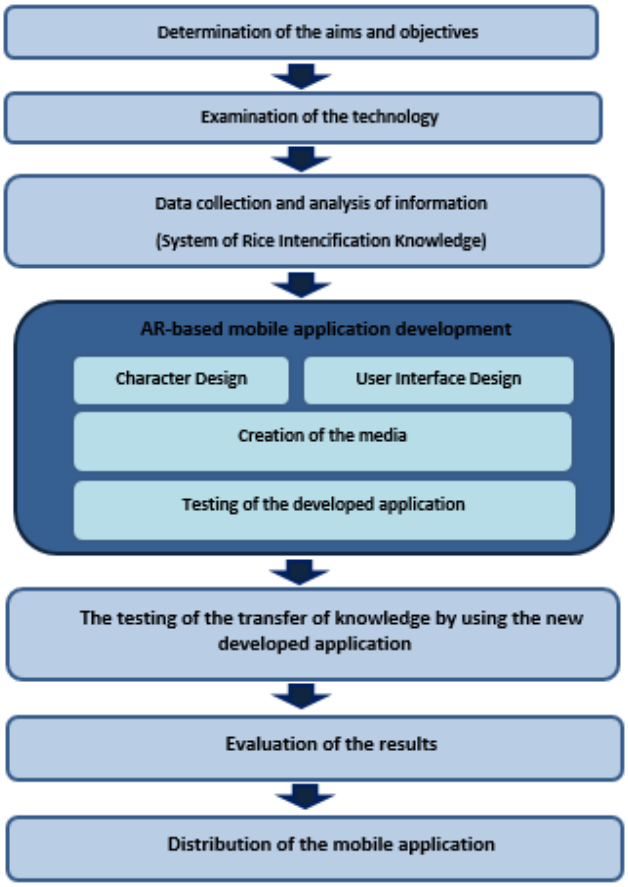

Fig. 2 An experimental process of the augmented reality-based mobile application for knowledge transfer in the system of rice intensification development

IV. EXPERIMENTAL RESULT

In this research, the participants jointly responded to an evaluation model, namely farmers and person that are interested in the System of Rice Intensification based on the five regions of Thailand divided into rice growing areas based on the statistics of the [16], namely the northern region, central region, the eastern region, the northeastern region and the southern region with a total amount of 512 people with the majority of the sample group being female (322 people, calculated as 62.89%), and having an age higher than 50 years (181 people, calculated as 35.35%), followed by the age group between 41 to 50 years (121 people, calculated as 23.63%), the majority of the sample group have an educational level that is lower than a bachelor's degree (362 people, calculated as 70.70%) and the most common occupation as farmers (165 people, calculated as 32.23%). A large segment of the sample group do not use other applications that fall outside of online social media (197 people, calculated as 38.48%) and the majority of the sample group do not install applications used in learning things that they are interested in on their mobile phone, such as applications for learning languages or applications providing information on common household

medications, etc. (268 people, calculated as 52.34%).

4.1.Results from the development of the application on mobile devices for the transfer knowledge about the System of Rice Intensification with augmented reality technology, as shown in Fig. 3.

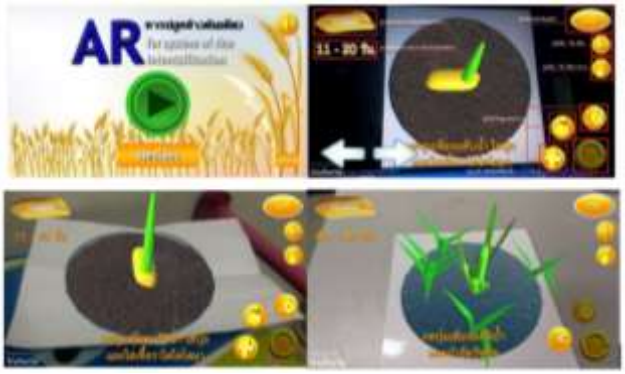

Fig. 3 The demonstration of the interfaces used in the augmented reality-based mobile application for knowledge transfer in the system of rice intensification

4.2. Results of the evaluation of the efficiency of the application that was improved

The results regarding the efficiency of the application on mobile devices in order to transfer knowledge about the System of Rice Intensification with augmented reality technology by using a 4-point questionnaire was divided into the test before the trial of the media that created 10 items and the test after the trial of the media that created 10 additional items for a total of 20 items by the sample group used in this research with a total amount of 500 people, namely farmers and persons that are interested in the System of Rice Intensification divided into areas according to the [16] comprising five regions, namely the northern region, the eastern region, the northeastern region and the southern region, as seen in Table 1.

TABLE 1
EFFECTIVENESS INDEX VALUES OF THE APPLICATION ON MOBILE DEVICES FOR TRANSFER OF KNOWLEDGE ABOUT THE SYSTEM OF RICE INTENSIFICATION WITH AUGMENTED REALITY TECHNOLOGY.

Sample group divided into agricultural areas according to the Rice Department	Pretest Score	Posttest Score	Amount (people)	Effectiveness Index value (EI)
Northern region	392	784	104	0.6049
Eastern region	537	875	100	0.7334
Central region	311	757	100	0.6473
the Northeastern region	571	875	100	0.7086
Southern region	366	844	108	0.6695
Total	**2,177**	**4,135**	**512**	**0.6653**

As can be seen in Table 1, the testing of the efficiency of innovation by using the Effective-ness Index (EI) and setting the criteria of the Effectiveness Index that should have a value from 0.50 and up will show that the innovation has the efficiency [18]. The total Effectiveness Index value of application on mobile devices for the transfer of knowledge about the System of Rice Intensification with augmented reality technology is equal to 0.6653, which indicates that after the sample group used the application that was developed, they had a knowledge increase of 0.6653 or 66.53%. It can be summarized that after the sample group used the application that was improved, they had increased knowledge in every region, which shows that the application with augmented reality on mobile devices for the transfer of knowledge about the System of Rice Intensification that has been improved is appropriately efficient.

V. DISCUSSION

Based on the research findings, the development of the application with augmented reality on mobile devices for the transfer of knowledge about the System of Rice Intensification, it was found that augmented reality technology has the potential to be used for work in many aspects [7] with the application of the theoretical principles to create the system in a virtual world overlapping with images that can actually be seen in the real world through smart phones, which will allow the users to be able to see virtual images with a view of 360 degrees without users needing to go to the actual location [9], [10] by employing the augmented reality technology, users have satisfaction at a high level, which is in line with [17], [8] who found the results that the application is an intermediary that becomes one part of the use of the transfer of knowledge that is interesting and has virtual reality enhancing the occurrence of memorization. Regarding the next part of the design for users, the user Interface must be considered as important, as in the research results, it was found that the sample group had satisfaction at a high level with the design in the application that is attractive, interesting and able to respond to doing work accurately by having the creation of the user manual of the application in order to function as a set of guidelines in its correct performance according to the steps to reduce errors in the actual performance. Furthermore, there is also the creation of the highest efficiency. and in addition, there is still the way for people that must study, the person that are interested, and the people that must study by themselves.

VI. DISCUSSION

In conclusion, this AR-based mobile application about the System of Rice Intensification is able to apply for learning prior to actual performance by being able to learn in any place and any time, resulting in a process of life-long learning. However, in this study we examined the effective of the new knowledge transfer method by compared the learning achievement before and after learning with the new developed AR-based mobile application. For future work, it is necessary to evaluate the farmer success after learning from this AR-based mobile application in order to confirm the impacts of the new method of SRI knowledge transferring.

ACKNOWLEDGMENT

This work was supported by the National Research Council of Thailand (NRCT) and Suan Dusit University.

REFERENCES

[1] J. Rungcharern, Highland Research and Development Institute (Public Organization), Rice Intensification with less water in the high space area, Bangkok, 2017. [in Thai]

[2] Institute for Sustainable Agriculture Communities, System of Rice Intensification, Chiangmai, Thailand, 2010. [in Thai].

[3] Appropriate Technology Association, System of Rice Intensification, Pak Chong, Thailand, 2014. [in Thai].

[4] M. Ibáñez, and C. Delgado-kloos, "Augmented reality for STEM learning: A systematic review. *Computers & Education*, vol. 123, pp. 109–123, 2018.

[5] C. Shao-Chen, and H. Gwo-Jen, "Impact of an augmented reality-based flipped learning guiding approach on students' scientific project performance and perceptions," *Computer and Education Journal*, vol. 125, pp. 226-239, 2018.

[6] M. Stier, and D. Grüntjens, "Factors for Knowledge Transfer in Mobile Gamebased City Tours on Smartphones," In *Proceedings of International Conference Virtual and Augmented Reality in Education (VARE 2011)*, pp. 1–8, 2011.

[7] T. Praprukchop, "Utilization and satisfaction of institute of technologys' students in Kasetsart University via AR and QRC," *PULUNET Journal*, vol. 4, no. 2, pp. 38-45, 2017.

[8] S. Krongpong, and V. Kemakarothai, "Introduction of services of the Kasetsart University Library through AR and QRC," *PULUNET Journal*, vol. 4, no. 2, 2017.

[9] S. Byung-Kuk, P. Jungsik, and P. Jong-Il, "3-D visual tracking for mobile augmented reality applications," *Proceedings of 2011 IEEE International Conference on Multimedia and Expo (ICME)*, Barcelona, pp. 1-4. 2011.

[10] T. Chung-Hsien, and H. Jiung-Yao Huang, "Augmented reality display based on user behaviour," *Computer Standards and Interfaces*, vol. 1, pp. 171-181, 2017.

[11] F. Saltan and Ö. Arslan, "The use of augmented reality in formal education: A scoping review," Eurasia Journal of Mathematics Science and Technology Education, vol. 13, no.2, pp. 503-520, 2017.

[12] A. E. Widjaja, J. V. Chen, Q. A. Ha, and B. Lin, "Knowledge sharing in open source mobile applications project," *International Journal of Mobile Communications*, vol. 15, no. 3, pp. 306-328, 2017.

[13] B. András, and M. György, "Supporting the M-learning based knowledge transfer in university education and corporate sector," in *10th International Conference Mobile Learning 2014*, pp. 339–343, 2014.

[14] Z. He, L. Wu, and X. R. Li, "When art meets tech: The role of augmented reality in enhancing museum experiences and purchase intentions," *Tourism Management*, vol. 68, pp. 127–139, 2018.

[15] L. Xie, C. Wang, and Y. Bu, "TaggedAR: An RFID-based approach for recognition of multiple tagged objects in augmented reality systems. *IEEE Transactions on Mobile Computing*, vol.1, 2018.

[16] Rice Department of the Ministry of Agriculture and Cooperatives, Report on Rice Production Situation: Production and Marketing Plan for Round 1 of 2017/18, 2017. [in Thai]

[17] N. Dissacharern, K. Ponyiam, P. Wungkahad, and P. Jarujumrus, "Development of learning media, atomic structure and chemical bonding with emerging technology," *Journal of Science, Technology and the Environment for Learning*, vol. 5, no. 1, pp. 21-27, 2014.

[18] Department of Academic Affairs of the Ministry of Education, Research for development of basic education curriculum, Bangkok, 2002. [in Thai].