Yang, J. C. et al. (Eds.) (2018). Proceedings of the 26th International Conference on Computers in Education. Philippines: Asia-Pacific Society for Computers in Education

A Development of 3D Augmented Reality Mobile Application to Facilitating Ecotourism-based Herbal Learning in MFU Botanical Garden

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Abstract: Visiting a botanical garden to study plants are difficult for tourists to understand according to their scientific information and contexts truly. With ecotourism-based learning, the tourists can enjoy learning with the guiding support; moreover, the traveling experience becomes more interesting. In this perspective, Augmented Reality technology could help enhance this learning experience by providing a beautiful graphics and sound effect. 2D and 3D graphic could be able to describe herbal plant's character in this botanical garden. The visitors can study the plant by both of the real herbal plants and augmented reality data technology. Before conducting this project, all requirements have been gathered from botanical garden officers and visitors, which mostly preferred to have the freedom to learn by their own paths while enjoying the garden. Therefore, the mobile application has been designed and developed. The visitors can use the developed mobile application and walk through the garden in a self-learning environment. To make sure that the visitors could be able to seek for herbal plants that they want to study, the application creates a realistic 3D plant model, which make it more convenient to match the data with the real trees. The plant's information could present a plant's character and how the plant has been used by local people. This enables visitors to study the garden from the graphic and sound of the application. This mobile application can be further developed in the future, which could create more engaging and meaningful learning activities in the gardens. The visitors could have fun while learning at the same time from the mobile learning activity.

Keywords: Augment Reality, Mobile Learning, Botanical Garden, Herbal Learning, Ecotourism

1. Introduction

In Thailand, people use many types of herb to flavor their national food, which makes its flavor famous all around the world. Furthermore, it also has properties to cure many diseases such as a cough, fever that could be cured with lemongrass (Nambiar & Matela, 2012). As a result, many Thai farmers decided to increase green production line for sale. Some villages invent a way to keep and transform their products to increase the value. Thailand exports herb product has a value of more than 100,000 million baht a year. The countries that have a high value in exporting herb product include France, Germany, and Japan, which tend to continue increasing in value (Posttoday, 2017).

Many types of the herb have been planted in Botanical Garden that includes bush, vine, climber, annual crops, flowerer, and herb. Each garden has the specific plants, which decided by topography and weather in that region or some garden could have compiled specific species plant from another region because it has a suitable environment. Botanical Garden is a data source for scientific, research and development. It also has ecology to be able to study the living thing such as insect, bird and small reptile. Typically, most of Botanical Gardens have two problems that happen

all the time. Firstly, many researchers usually have a problem with dividing the type of plant because many gardens do not have any specific plant's label, which could be lead to a misunderstanding. Secondly, although they have a label, it usually doesn't have enough space to put on the data information of that specific plant that couldn't give all of the meaningful data of each herb. Herbal research and development could be easily found everywhere in Thailand.

It has been interested in many research studies; for example, Chokevivat (2005) reported that Herbal medicine could be separated into three education majors, including Thai traditional medicine practitioners, applied Thai traditional medicine practitioners and Practitioners with Bachelor Degree in Thai traditional medicine. To start with the first one, student who wants to join Thai traditional medicine practitioners course does not need to have a high school degree at all and this course focus on medical plants, animal anatomy parts, and minerals that are used as medicinal ingredients. To continue with applied Thai traditional medicine practitioners, for students who want to participate in this course has to graduate from a high school degree. In this course, students have to study life science knowledge such as human anatomy, physiology, biochemistry and botany as a prerequisite for knowledge. However, they have to study Thai traditional pharmacy and medicine at the same time. The last one is Practitioners with Bachelor Degree in Thai traditional medicine, which focuses on both of Thai complementary medicine and Thai traditional medicine. For high school students, herbal study has been taught in biology and physical education subjects. Some schools have their botanical garden, but the types of herbal are not diverse. In 1992, Her Royal Highness Princess Maha Chakri Sirindhorn had a Royal initiation to the Lord Chamberlain to conserve plant genetics. Plant Germplasm was established in 1993 at the Royal Chitralada Projects and plant genetic conservation activities were started. Botanical garden in school is also one of the activities inside the plant genetic conservation activities. Nowadays, there are around 200 schools in Thailand that have been participated in this activity.

Ecotourism is a journey that tourists seek to study natural and culture in that area, which makes it interested from every country these days. Wearing and Neil (1999) said, "As much about environmental education, the fostering attitudes and behavior that is conductive is maintaining natural environments and empowerment of host communities, as it is about fostering a sustainable industry." Van Winkle and Lagay (2012) said, learning throughout the age of man is learned in diverse contexts and travel presents a unique learning environment enabling both unplanned and planned opportunities. Ecotourism is a tourist that will absorb the things that travel through the contact and visual experience.

Augmented reality is one of a new way to present the data knowledge in 3-dimensional graphics and also include sound effect too. It is remarkably effective in term of presentation. The data that could be bored by some audience could be amused and presented on the mobile device or tablet, which makes the audience in Botanical Garden be able to choose only part of data they want to study by walking through the garden. The mobile device or tablet is going to be a tool for them to do self-study. Augment reality technology allows learners to be free to see what they want to learn. It offers real-time knowledge representation, allowing learners to control their visibility. Another advantage is if the audience is unable to find the data. They could be able to restudy the data by themselves. Kaufmann and Schmalstieg (2003) experiment by use AR technology with construct 3D mathematical and geometrical models. From their evaluation results that AR-based construction environment encourages experimental learning and improves spatial skills for students.

Based on the limitations of learning herbal plants in the botanical gardens, therefore, this paper endeavors to address these issues by taking advantage of AR technology and the eco-tourism concept to develop a mobile application for tourists. The design of this application has been made after a careful process of gathering requirements from the local staffs and visitors. This developed application could enhance the tourists' learning and travel experience by having more freedom to learn by having their own learning paths. Moreover, AR technology on this application facilitates this mobile-based learning by presenting insights information about the plants in beautiful 2D and 3D graphics with brief sound narration. The presented information will be shown in corresponding with the herbal plant that is scanned. This paper implemented in MFU Botanical Garden contexts. The results of this application shed the light of alternative means of simultaneous learning and traveling for the more meaningful learning experience.

2. Related Study

2.1 Botanical Garden

From history, the main objective for initiating Botanical Garden was to collect and preserve medicinal plants (IUCN, 1989). However, the roles of a modern botanical garden have moved away from plant collection. Three major roles of modern botanical gardens have to offer which are as follows; Public education, ex-situ conservation, and scientific research. In addition, there are 12 types of botanical gardens in the world such as 'Classic' multi-purpose gardens, ornamental gardens, historical gardens, conservation gardens and university gardens, etc. (Jackson & Sutherland, 2000). Interestingly, Botanic gardens (including arboreta and related research facilities) are one of the main foundations elaborated in ex-situ conservation of wild species with 105,634 species (30% of known plant diversity) that was occupied in the world's botanic gardens (Mounce, Smith, & Brockington, 2017). Furthermore, the International Agenda including the Convention on Biological Diversity (CBD) and the Global Strategy for Plant Conservation (GSPC), indicates the essential for botanical gardens worldwide to aim education as a significant part of biodiversity conservation and focus on the necessity to rise the understanding and awareness of the importance of biodiversity (United Nations, 1992; CBD, 2002). The 'International Agenda' (Jackson & Sutherland, 2000) provides a guideline for botanical gardens as it lists a number of criteria that botanical gardens should attempt to accomplish. The basic principles of botanic gardens including (1) having scientific basis for their plant collections, (2) offering sufficient papers of the plant collections, (3) permanent associations, and (4) welcome to the community and to the civic scientific. The scientific concept beyond the existing plant collections is a key characteristic that differentiates botanic gardens from common ornamental gardens.

Recently, education is turning into one of the ultimate tasks for modern botanical gardens. The most agreement would be on the four crucial roles of public display, research, education, and conservation, the latter recently has developed a main attention of many botanical gardens (Ballantyne, Packer, & Hughes, 2008; Chen, Cannon, & Hu, 2009; Donaldson, 2009). Botanical gardens around the world are varying broadly in design and purpose, but most are usually related with environmental conservation, education, or historical interpretation. The research study indicated that botanical gardens would be operate to provide a rich, overall experience that supports relaxation, other than sustaining a healthy, interesting, and diverse collection of plant resources that allows visitors to experience new plants and promote occasions for learning (Wassenberg, Goldenberg, & Soule, 2015). It may surprise many that botanic gardens and universities share a common heritage because the founding of the physic gardens was often associated with universities. So it emphasizes that, botanical gardens are living laboratories of colleges and universities. However, botanical gardens are not replacements for study in natural areas but would be noticed as complementary, and they offer several benefits to the next generation. Among the advantages of botanical gardens are as follows; convenience and accessibility, diversity, global perspective, repeat visits, aesthetics, outdoor learning and human-nature relationship (Bennett, 2014).

Nowadays, from the remarkable new Gardens by the Bay in Singapore to London's own legendary Royal Botanic Gardens at Kew, the world's botanic gardens collectively host 500 million visitors a year. Subsequently, botanic gardens can supply the compulsory education, citizen science and information to facilitate plant conservation action through the wider society (Mounce, Smith & Brockington, 2017). Many gardens are considered famous tourist attractions in their own right. He & Chen (2012) conducted a study in five botanical gardens containing visitor education centers (VECs) throughout mainland China with the purpose of understanding the range that VECs can improve the educational utility of botanical gardens. In all five botanical gardens were examined the visitors who the VECs believed that they gained significantly more knowledge compared to those who did not visit VECs. The research results highlight the meaningful of developing educational amenities such as setting up VECs to allow botanical gardens to perform better role in biodiversity conservation. Ward, Parker, & Shackleton (2010) informed an evaluation of the use and appreciation of six national botanical gardens as urban green spaces in South Africa. The gardens provided various advantages in terms of conservation, education and recreation while the mainstream of users visited the gardens for leisure and psychological reasons rather than educational ones. Most visitors fascinated the conservation dimensions of botanical gardens, and sensed that

there was inadequate public green space in their place. If botanical gardens are to foster community understanding of education and environmental awareness. The visitor research is needed to inform the design and delivery of garden experiences that continue to attract, innovate and inspire visitors.

2.2 Ecotourism-based Learning

In 2002, the United Nations (UN) declared the International Year of Ecotourism and in this year, the World ecotourism Summit in Québec was held, ecotourism has become a famous global strand of sustainable development (Walter, 2010; Wood, 2002). One of the most significant definitions of ecotourism is a low effect nature tourism which contributes to the conservation of species and habitats either directly through a contribution to maintenance and/or indirectly by providing profits to the local community sufficient for the people to value, and consequently look after the wildlife zone as a source of earnings (Goodwin, Kent, Parker, & Walpole, 1997). The better definition of Ecotourism is included with conservation, education, ethics, sustainability, impacts and local benefits (Fennell, 2001). Furthermore, ecotourism can contain both cultural and environmental tourism and additionally, welfares to the local people would be an integral part of the activity which is helping the tourist to learn more about living with natural and culture in sustainable way. It is interested by many countries not only making a sustainability tourism but it also can create many tourism activities and money for local people. It is one of the biggest industry on the earth that has an increasing rate of 10-15% a year (Scheyvens, 1999).

Ecotourism is a tour in a natural environment, which sometime is a place that made by the natural or human. As the result, Ecotourism has 3 common concepts, which included natural-based, education and sustainable. It must be included with economic, social criteria and focusing on conserving a society and culture which is the main mechanism of this industry. Environmental education is an important element in ecotourism for helping tourists gain more awareness and understanding of natural phenomena. Ecotourism can help providing an experiential and emotional element to learning in nature that can have more behavioral effects than classroom and online learning about nature. They proposed the model of education goals and outcome which are consist of awareness, emotional, ethical and volitional (Osland & Mackoy, 2015). Ecotourism is not only a new way of tourism but it makes tourist attraction to be a data sauce of nature and culture which are one of the most important process for learning system. The tourist is going to absorb the knowledge by themselves for example, an elephant touring in Thailand which using the elephant for traveling in nature environment. The tourist would be able to study the elephant life and a social link between mahout and elephant that has been greatly interested by many tourists. On the other hand, having too many elephants is expensive because mahout has to pay a lot of money for the food and elephant accommodation which could be lead to losing money.

The hearth of Ecotourism is a learning activity at the same time as touring, which going to create the participation during the activity. This will be lead to the 3 main concept of Ecotourism that include natural-based, educational and sustainability. Eco-tourism guide is being the facilitator for tourists to experience nature. It seems like Eco-tourism guide lies at the heart and soul of ecotourism because they have many responsibilities such as expected to provide organization and management of the tour, facilitate interaction with the host community, provide leadership, and especially deliver interpretation. The role of the tour guide is not only an important one, but also one of influence therefore the well training of them is needed (Skanavis & Giannoulis, 2010).

As the consequence, the idea to create sustainability ecotourism should come up with learning the natural to create last long knowledge for tourist by using many ways of learning strategies. We are also thinking that innovation may be help Eco-tourism guide to organize a better tourism.

2.3 Mobile Augmented Reality (AR)

AR or augmented reality is the combination between the real objects and digital technology. In the past few years, developers must use a tool headset to using AR technology. But in 2008, a new software was created, which make the handheld mobile and console to be able to use this technology without the headset. Therefore, this makes AR technology become popular in many industry such as education, game, medical, entertainment and tourism. The main purpose of AR is to present the data

content in 2D or 3D graphic by putting the virtual object on the real world object that could show the simple graphic in the picture below (Carmigniani, Furht, Anisetti, Ceravolo, Damiani & Ivkovic, 2011). The main function of AR technology could be divided into 2 functions, which are tracking and reconstruction/recognizing. To begin with tracking, the trigger picture is going to be detected by a mobile device's camera. The detection will be marked by an interest point of each individual picture. Normally the tracking position will be multiply marked all over the picture for accuracy. Furthermore, the color has to be highly contrasted between each pixel, which has been used by many programs such as Vuforia. To continue with reconstruction and recognizing, the program will overlay the virtual object on the trigger picture. The virtual object viewer application could be easily found everywhere such as LayAR, Ausasma. On the other hand, if the developer want to create their own application, they could create it on a personal computer that has Unitty3D and Vuforia, which could build a mobile application or personal computer (Carmigniani, Furht, Anisetti, Ceravolo, Damiani & Ivkovic, 2011).

Augmented Reality Technology has been applied with many research and education. Shelton and Hedley (2002) has tried to use AR with education by using ARtoolkit to teach an undergraduate geography student about "Earth-Sun relationships". The result after using the AR exercise is the improvement of the student in term of understanding. Chang, Hou, Chang, Sung, Chao and Lee (2014) used AR with art gallery visitors. The application has been use on mobile device for guiding and supporting the visitor in an art gallery. Moreover, they also use AR technology for teaching grade 1 mathematic in 2016. 3 classrooms were using the application, which has divided Math in many categories that included difficulty level. Furthermore, the application is allowed for lecturer to matching AR with their curriculum topic of mathematic (Radu, McCarthy & Kao, 2016). In the same year, Akçayır, Akçayır, Pektaş and Ocak (2016) also used AR in science laboratories for study the effect of augmented reality on university student in laboratory skills and attitudes toward science laboratories.

This research want to improve skill of the students and also builds a positive attitude toward physic laboratories. AR technology could be used in many industries, which create a learning activity via 3d image and sound because they are learning and playing AR application that has an animated graphic at the same time. Lastly, it could be used on any mobile device, which makes it very easy for everyone to get a hand on them.

3. Methods

3.1 Contextual Analysis

Mae Fah Luang University (MFU)'s botanical garden has been divided into many sections depend on the type of plants such as herbal garden and evolution garden. MFU botanical garden has more than 5,000 plants and 388 types of herb, which has been set up on the land of 6.72 acres. Most of the plant can cure many diseases. To make it easy for MFU botanical garden visitors, the garden has been separated into six sections divided by their properties that included (1) Herb treatment for skin disease, Defecate and insect repellent, (2) Herb treatment for alimentary system, (3) Herb treatment for circulatory system, (4) Herbal for analgesia, Anti-inflammatory and analeptic, (5) Poisonous herbs and herbal for detoxicate, and (6) Decease dyslipidemia herbs, Anarcartharsis and Antitussis herbs, as shown in Figure 1. The garden has a variety of visitors such as high school student, Thai traditional medicine student, state agency, private cooperation and general tourist.

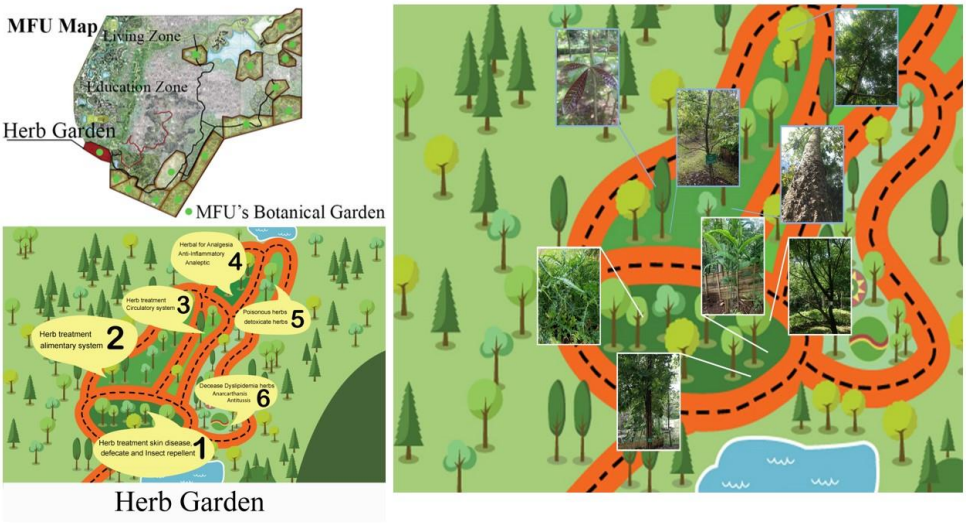

Figure 1. Mae Fah Luang University's Botanical Garden

Inside the garden have too many plants, which make it difficult to study. To make it more convenient, the university decided to separate the herbal into six zones by their properties. The benefit of separation is to make it easier for the visitors to access the source of herb that they want to study. Nevertheless, it also groups the herbal plant that has the same medical effect too. Table 1 presents the information of the herbal plants, both common name and scientific name, used in the mobile application.

Table 1 *Herbal Plants used in The Developed Mobile Application*

 Galanga: *Alpinia galanga* (L.) Willd.)	 Menthol: (*Cinnamomum Camphora* (L.) J.Presl)	 *Acanthus ebracteatus* Vahl	 Vitex glabrata: (*Vitex glabrata* R.Br.)
 Cotton tree: (*Bombax ceiba* L.)	 Cinnamon: (*Cinnamomum spp.*)	 White cheesewood: (*Melodorum fruticosum* Lour.)	 Cananga: (*Cananga odorata* (Lam.) Hook.f. & Thomson)

 Wild Himalayan Cherry: (*Cerasus cerasoides* (Buch.-Ham. ex D. Don) S.Y. Sokolov)	 *Osmanthus fragrans* Lour.	 Gardenia carinata: (*Gardenia carinata* Wallich.)	 Milk bush: *(Euphorbia tirucalli* L.)
 *Azadirachta indica* A.Juss.	 *Carmona retusa* (Vahl) Masam.	 Teak: (*Tectona grandis* L.f.)	 *Baccaurea ramiflora* Lour.

3.2 Application Requirement & Analysis

Application requirements were collected from a garden officer. They want an activity that would be able to teach the visitor about herbal plants common names and a scientific name of the herbal plants. They want visitors to learn about the physical description of each specific plant, and the most important is the data knowledge of each herbal medicine properties. Some of them might be used as a cooking ingredient or everyday life tool. The user interface must be simple and easy to use and must be able to use by every age of visitor. After getting the requirement, the research team has conducted a survey in the garden and found that the internet signal is weak, which could be a problem for the application that uses the internet. With all of this information, the research team going to develop the application continually. The six zones that have been divided are connected with a walkway that doesn't have any basic navigation such as a guidepost or location map. As a result, many visitors get lost inside the garden, and the garden still lacks a tool or application to create an activity for tourist. The primary requirement of this application is to present a 3D graphic that includes a photo-realistic texture of the herbal plant, which is one of the most important data to present the physical description. Because sometimes the different types of herbal plant are planted in a close distance that makes it very difficult for visitors to matching the label with the herbal plant. Then, the application must have a vocal sound to describe the data that has been written on the label such as the medical effect and intellect from a local people.

4. Results of Application Design and Development

To create a learning activity for the botanical garden, the augmented reality technology application has been employed to present the plant information in the 3D graphic. In corresponding with the botanical garden requirement, the application has been divided into three parts, see Figure 2. The first one is a data source which included 2D graphic (UI) and information. The second one is the 3D models of every herb which could present the detail of trunk, branch, and leaf of each herb. The

audio content could describe each herb properties in a short time (no more than 30 seconds). The last part, it detects the image-based target for showing 3D models. All of these will create a learning activity in the garden which could be installed on any mobile devices. The garden visitors could download the application and gains a piece of knowledge by using the application to scan the trigger which has been installed in front of every herb in the garden, and all of the data will be presented on the visitor's mobile device.

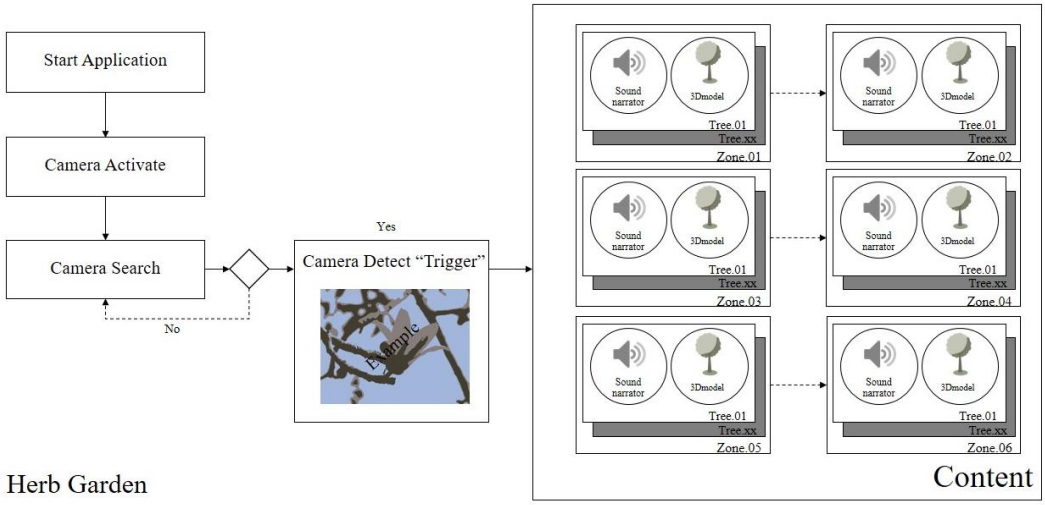

Figure 2. An Overall Structure of The Developed Mobile Application

Each part of the application has been developed from several software. The first part of the application has been created to be the same model as a game, which makes a Unity3D (Helgason, Francis & Ante, 2005) program and the C# programing language become the primary tool to complete the first part. All of the 3D models have been made by Autodesk Maya (Walker& Drake, 1982) which could be downloaded from an Autodesk website. However, the 3D model could not be completed with a texture over them which could be gathered by photographing from each part of the herbal plant (trunk, branch, and leaf) which make the 3D models have a super realistic look. The identifying part is made by Vuforia (Heppelmann, 2008) which help to create an image target and AR Camera. The image target is a trigger image that could be scanned by a mobile device. The AR camera is the main function for scanning the trigger picture which could present 3D graphics models over the trigger picture, as presented in Figure 3.

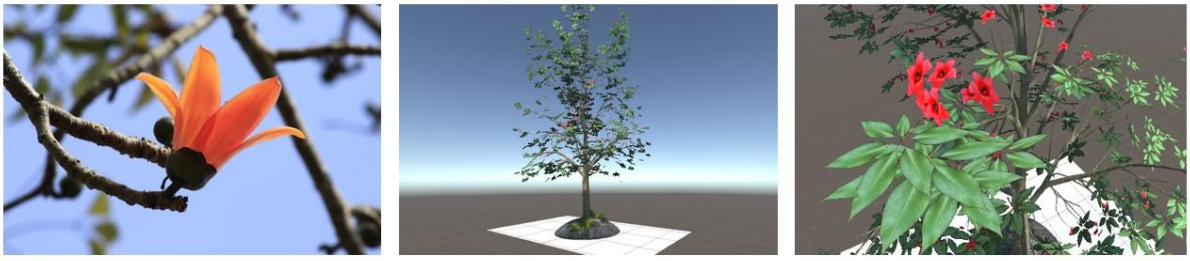

Figure 3. Example of Trigger Image and Information shown in The Application

For make it simple as much as possible is the key idea of this application because it is designed to be used outdoors. To make it comfortable for the garden visitors, the application could be downloaded from the entrance area of the botanical garden. In the learning activity, visitor's mobile device is an essential tool for learning. Visitors could walk around six zones of the garden, and if visitors want to use the application, it could be activated by pressing the start button which could activate the AR camera. The AR camera is going to be a tool for scanning the trigger image

and after the image has been scanned, the 3D models and sound effect will be automatically presented on the mobile device, as shown in Figure 4. If the visitors want to study another herbal plant, they to move their mobile device to scan another trigger image which could provide another herbal plant data.

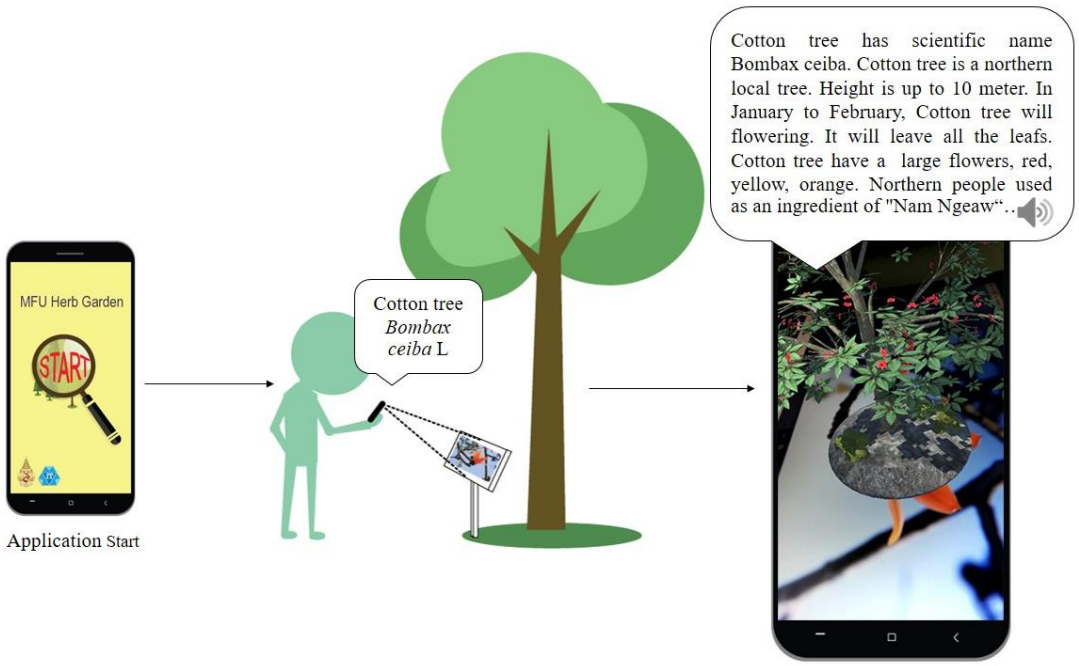

Figure 4. Illustrations of How Application Works

Acknowledgements

The authors would like to acknowledge Dr.Jantrararuk Tovaranonte, School of Science, Mae Fah Luang University for her support and suggestions on the invaluable information of MFU Botanical Garden. Also, the special thanks direct to the botanical garden's staffs, School of Information Technology in Mae Fah Luang University for their incredible contributions and technical support throughout this project.

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