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碩士論文

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探究行動學習環境中學生之學習成效與態度
——以「大師闖師大」為例

**An Investigation of Students' Learning Outcome and Attitude in
Mobile Learning with NTNU Campus Tour Application**

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誌謝

初至師大科學教育研究所攻讀碩士時，對於科學教育領域尚不熟悉，且對於研究方向也毫無頭緒，自修習了張俊彥教授所教授之科技融入科學教學相關課程後，就開啟了我對於科技融入科學教學的研究興趣。感謝指導老師張俊彥教授在研究的過程中提供充足的研究資源，以及在每次的討論會議中給予我指導與建議，此外，亦予以相當大的自由空間讓我能從事自己有興趣的研究主題。張俊彥教授對於新興科技保有高度興趣，且樂於研究它們應用於教學上的成效，對於任何事物都有研究的精神，這樣的精神十分值得我跟隨。感謝論文口試委員楊芳瑩教授與張月霞教授在口試時提供許多研究上及論文撰寫的建議，讓我受益良多。再來，感謝研究團隊銘照學長、慶源學長、庭光學長、佑達學長提供研究方向的建議，以及協助解決研究過程中的困難；也感謝研究夥伴承佑、漢森、哲民、柏承的協助，使得研究教學活動得以順利進行。沒有大家的幫助，我一個人是無法完成整個研究，衷心地感謝大家！最後感謝我最親愛的家人，在我碩士生涯中全力地支持我、鼓勵我，讓我可以全心進行研究，家人的支持是我前進動力。感謝姊姊意雯在我遇到困難與挫折時所給予的幫助及鼓勵，英文寫作並非我的強項，但因姊姊的協助這篇論文才能夠順利完成，謹以此篇論文獻給我最愛的家人。教育及研究的道路依舊漫長且沒有終點，期許自己能夠保持熱忱，往更高遠的目標前進。莫忘初衷。

中文摘要

近年來，無線技術的進步及行動技術的發展，使得行動裝置變得越來越普及。行動學習也成為一個新興的學習方式，它可以被設置在不同的學習環境中。在本研究中，研究者發展了一套具有校園導覽與科學教育雙功能的應用程式，此應用程式稱之為「大師闖師大」(NTNU Campus Tour application)。同時利用大師闖師大應用程式設計一戶外行動學習活動，此活動稱為「師大闖關」(NTNU Campus Tour activity)。

本研究的對象為就讀國立台灣師範大學的師資培育生，其中男生有 14 位，女生有 17 位，共 31 位學生。藉由學習成就測驗來檢測學生體驗完大師闖師大應用程式與師大闖關活動後之學習成效，以及使用態度問卷來收集學生對於行動學習的態度。

學生參與行動學習課程後，在學習成就測驗上的表現明顯進步，且七周後依舊記得學習內容。學生對於行動裝置應用於學習是持正向態度的，他們認為網路搜尋及數位擷取功能對於學習最有幫助。此外，學生也表達日後使用行動學習的正向意願。

關鍵字：行動學習、擴增實境、大師闖師大

Abstract

In recent years, the advance of wireless technology and the progress of mobile technology cause mobile devices become popular. Mobile learning is a innovative learning approach. It can be embedded in diverse learning environment. In this reserch, the NTNU Campus Tour application was developed with a dual purpose of NTNU campus guide as well as outdoor mobile science education which was developed as a challenge game called NTNU Campuss Tour activity.

The subjects of this research were undergraduate students who were pre-service teacher in Taiwan. There were 14 males and 17 females, totally 31 students. After students experienced the NTNU Campus Tour activity, their learning performance was evaluted by learning achievement test, and also attitude questionnaire to gather students' attitude toward mobile learning.

Students' performance in learning achievement tests was significantly improved after experiencing the NTNU Campus Tour activity and they still remembered learning content seven weeks later. Students held a positive attitude towards mobile devices which were applied to learning. They considered that internet search and digital capture were the most helpful in learning. Moreover students were willing to use mobile learning in the future.

Keywords: Mobile learning, Augmented reality, NTNU Campus Tour Application

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1. Introduction

1.1. Background

According to the report, Our Mobile Planet, from Google and Ipsos MediaCT, the penetration of Smartphone is rising in the whole world as shown in Figure 1 (from <http://think.withgoogle.com/mobileplanet/en/>). In Australia, USA and UK, the penetrations of Smartphone are already over 55% in 2013. In Taiwan, the penetration of Smartphone had increased a lot in the past three years. In 2011, there was 26.2% people own Smartphone, till 2013 the number of Smartphone penetration increased to 50.8%. Also, the most people who own Smartphone use the mobile internet (wireless network) everyday as shown in Figure 2. Over 90% Smartphone owners use mobile internet everyday in Australia (90%), USA (92%) and UK (91%). In Taiwan, 86% Smartphone owners use the mobile internet daily.

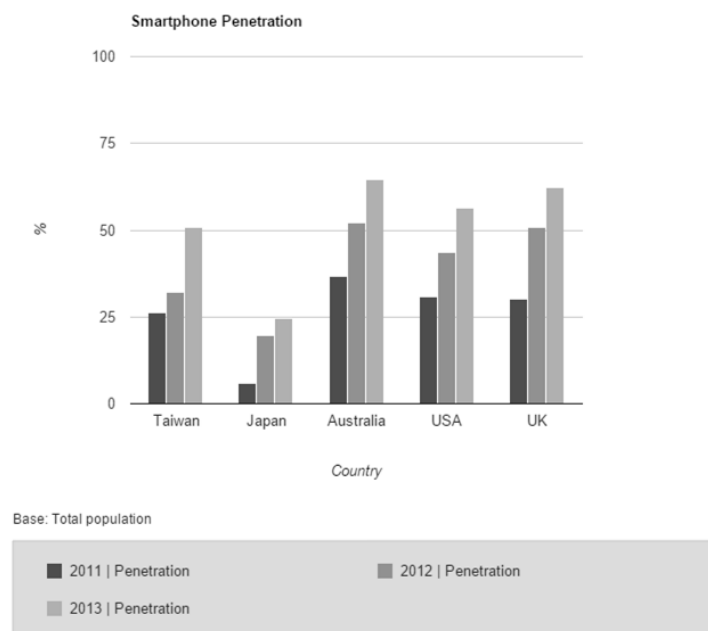


Figure 1: The Penetration of Smartphone from 2011-2013.

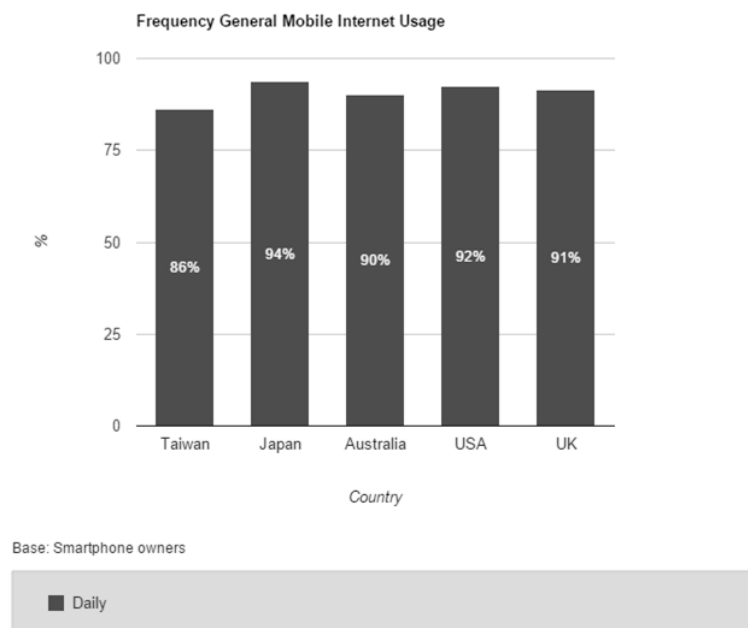


Figure 2: The Frequency of Mobile Internet Usage in 2013.

With the mobile devices and wireless network technology developed, UNESCO believed that the application of mobile technology in education can expand and enrich educational opportunities for learners in diverse setting (UNESCO, 2013). A new learning approach that applied mobile technology in education is called mobile learning. Mobile learning is going to be a trend for technology-mediated learning in the coming future (Wagner, 2005). Mobile devices have several functions which can be applied to educational use: electronic book readers, memorandum tools, image capture tools, sound recorders, video recorders, communication tools and so on. Moreover, Global Positioning System (GPS) and compasses can detect the user's location; motion sensors can sense device's motion state. These functions bring new approaches of learning (Johnson & Witchev, 2011). There are other factors that catalyze mobile learning: the broadband of wireless networks keep extending; battery life and memory capacity continue increasing and the most important thing is that some mobile devices like

Smartphone, tablet PC are always used in our lives, that is to say, it is no need to spend extra effort to adapt them (Wagner, 2005). Besides, nowadays many researches had reported the positive efforts of mobile learning (Chen, Kao, & Sheu, 2003; Chen, Kao, Yu, & Sheu, 2004; Dufresne, Gerace, Leonard, Mestre, & Wenk, 1996; Fjeld & Voegtli, 2002).

Augmented reality is a new technology which users are able to experience the world combined with the real world and virtual objects. This kind of technology with the perception feedback and high interaction features is suitable for science education to explain the abstract ideas in science. Now science education is able to take the advantage of the development of new technology like mobile devices, wireless network, augmented reality, ubiquitous computing and so forth. As science educators, the evaluation of these new technologies applied in science education should be done.

1.2. Mobile Learning (M-Learning)

1.2.1. The Definition and Features of M-Learning

What is mobile learning? According to Quinn “it’s E-Learning through computational devices: Palms, Windows CE machine, even your digital cell phone”. And also “M-Learning is the intersection of mobile computing and E-Learning: accessible resources wherever you are, strong search capabilities, rich interaction, powerful support for effective learning, and performance-based assessment E-Learning independent of location in time or space” (Quinn, 2000). Lehner and Nosekabel defined mobile learning as “any service or facility that supplies a learner with general electronic information and educational content that aids in acquisition of knowledge regardless of location and time” (Lehner & Nosekabel, 2002). Shepherd said that mobile learning is “mobile” (Shepherd, 2001). Vavoula and Sharples also indicated there are three ways

that learning could be considered as mobile (G. N. Vavoula & Sharples, 2002):

- learning is mobile in terms of space;
- it is mobile in different areas of life; and
- it is mobile with respect to time.

From these definitions of mobile learning, Chen and Kinshuk came into the conclusion of the definition of mobile learning: “a mobile education system should be capable of delivering education content anytime and anywhere the learners need it”, and “learning activities can be completed even when the learners and the teachers are both mobile” (Kinshuk & Chen, 2005).

Chang, Sheu and Chan referred to three elements of mobile learning (Chang, Sheu, & Chan, 2003):

- (1) The mobile learning device: The device should be small, light, portable, personal and equip with wireless communication function, such as a Personal Digital Assistant (PDA), a WebPad, a Tablet PC, a notebook, Smartphone or some specifically designed devices. It is also referred to handheld device in some researches.
- (2) The communication infrastructure: Communication infrastructure supplies mobile device to acquire learning materials or communicate with others like Infra-ray (IR), Bluetooth, wireless LAN, GPRS network, mobile network and etc.
- (3) A learning activity: Mobile learning activities can take place indoors or outdoors with either a single learner or a group of learners.

Klopfer, Squire and Jenkins pointed out some features of mobile devices as well (Klopfer, Squire, & Jenkins, 2002):

- portability,

- social interactivity,
- context sensitivity,
- connectivity, and
- individuality.

With the advanced in wireless communication technology, Chen, Kao and Sheu indicated six unique characteristics of mobile learning environment (Chen et al., 2003):

- (1) Urgency of learning need: Because of the wireless technology, learner can acquire knowledge or solve problem immediately.
- (2) Initiative of knowledge acquisition: Information obtain is always on the basis of the learners' requirement.
- (3) Mobility of learning setting: Mobile learning can take place at any time and any place. And the learning setting can be preplanned.
- (4) Interactivity of the learning process: Through mobile devices, learners can communicate with teacher, peers or others by mail, social application or other ways.
- (5) Situating of instructional activity: The learning is embedded into daily life. And the learning content can be presented in authentic context.
- (6) Integration of instructional content: Mobile learning can integrate many information resources and be applied to the cross-subject, theme-based learning activities.

Mobile learning is a form of flexible learning. Seppälä and Alamäki said “one feature of mobile learning is the opportunity to break away from teaching that takes place in a classroom, and to move to another location while communicating via information networks”, and “another distinctive feature of mobile learning is that it enables learners to enter an information networks at precise moment when necessary by

using a portable learning device and a wireless networks” (Seppälä & Alamäki, 2003).

1.2.2. The Learning theories of M-Learning

Naismith, Lonsdale, Vavoula and Sharples reported six existing theories of learning to evaluate the mobile technology in education (Futurelab et al., 2004). In this section, the concepts of the six existing theories are expounded; and examples will be presented in next section.

- (1) Behaviourist learning: Behaviourist theory is also called S-R learning theory.

From perspective of behaviourist theory, learning is a reinforcing result from the intersection of environmental stimulus and learners’ response. Applying this idea to technology, the materials which presented on the computer screen are stimulus, and the learners’ reactions are the response. The computer feedback system is the reinforcement. Mobile device with wireless network could provide these three functions. The use of mobile device to present learning materials is stimuli, the learners directly do actions on the mobile devices is response, and moreover the mobile devices provide the feedback is the reinforcement (Futurelab et al., 2004).

- (2) Constructivist learning: A major theme of constructivist theory brought up by Bruner is that learning is an active process in which learners construct new ideas or concepts based upon their current and past knowledge. According to constructivist learning framework, teachers should encourage learners to discover the new concepts by themselves. In order to let learners actively construct the knowledge on their own instead of positively receiving information from books or teachers, teachers are trying to create an environment to have learners learn in and construct the knowledge. Mobile

technology now provides the opportunity to create the environment in according with the reality (Futurelab et al., 2004).

- (3) Situated learning: Situated learning was developed by Lave et al in 1990s. The main concept of situated learning is that learning is not only to acquire knowledge by individuals but also to participate in the society. Brown, Collins and Duguid also pointed out the importance of apprenticeship (Brown, Collins, & Duguid, 1989). The teacher should work along with students on the problem which is created similar with authentic situation before they fully solved it. In other words, learning requires being presented in the authentic environment and learners participate in this environment to gain knowledge. With the small, light, easy-to-carry and equipped with the wireless internet mobile devices, now teachers could move the classroom to authentic environment (Futurelab et al., 2004).
- (4) Collaborative learning: Learning is a continuous conversation between different systems of knowledge (Pask, 1976). If person A could make sense of person B's description of what person B knows as well as person B also understand what person A's explanations of what person A knows. That is a conversation and also the way we share the understanding of the world to the whole world. A successful learning is that one is able to test ideas by performing experiments, asking questions, collaborating with others and to seek new knowledge. Mobile devices can easily communicate with the same or similar types and this feature enable learners to have a conversation easily, and share their data, files, messages, and findings easily as well (Futurelab et al., 2004).
- (5) Informal and lifelong learning: Vavoula, Sharples, Scanlon and Lonsdale

came into a conclusion of the definition of informal learning. Learning that happens within or alongside with the pre-established knowledge in main system of education with a teacher, a coach, a trainer, a mentor or a supervisor such as curriculum is formal learning. Instead, learning happens under the learners' control and without the pre-established knowledge is called informal learning. Informal learning could be happened by obtaining information accidentally via conversation, TV program, movie, radio, or newspaper. Mobile technologies with its reduced size, easy-to-carry, easy-to-use and wireless internet have the potential to facilitate informal learning via conversation, TV program, movie, radio, and newspaper (G. Vavoula, Sharples, Scanlon, Lonsdale, & Jones, 2005).

(6) Learning and teaching support: Jonassen, Peck and Wilson presented the roles of technology in education (Jonassen, Peck, & Wilson, 1999):

- Technology is a tool to support knowledge construction.
- Technology is an information vehicle for exploring knowledge to support learning by constructing.
- Technology is context to support learning by doing.
- Technology is social medium to support learning by conversing.
- Technology is intellectual partner to support learning by reflecting.

Kynäslahti gave three valuable elements for mobile technology in teaching and learning (Kynäslahti, 2003):

- convenience,
- expediency, and
- immediacy.

These three elements also confirmed in Seppälä and Alamäki's research on

mobile learning in teacher training (Seppälä & Alamäki, 2003).

1.2.3. The Examples of M-Learning in Science

From contemporary perspective of science education, science teachers are looking for ways to demonstrate the scientific experiments or micro-phenomenon in classroom or let learners observe the nature phenomenon outside classroom, and transform learners' experience of learning science into learning by doing it. Those ways are much more meaningful and useful for learners (G. Vavoula et al., 2005). In this section, how the mobile learning makes meaningful and useful science learning come true in and outside classroom is presented. Moreover, these examples are based on the existing learning theories mentioned in section 1.2.2.

- (1) Behaviourist learning: Wessels, Fries, Horz, Scheele, and Effelsberg introduced a highly interactive lecture. Teacher could interact with students by using mobile devices in wireless network environment. In the lecture, question was posted, and students' answers were evaluated and presented as graph on the mobile devices. In this environment, students paid more attention to the lecture and the interactivity in the lecture and students' learning became better (Wessels, Fries, Horz, Scheele, & Effelsberg, 2007).
- (2) Constructivist learning: Dufresne, Gerace, Leonard, Mestre and Wenk reported a successful classroom communication system which was considered based on the constructivist learning. Defresen et al described their experience in teaching first year physics students in the US with the classroom communication system called 'Classtalk'. There were three main equipments in this system: palmtop computers for students, a center computer for teacher, and the network to connect them. The 'Classtalk' helped teacher to do the

following works:

- To present the questions for the small group discussion, to collect the answers or ideas from the small groups, and to show the whole class the group discussion results.
- Not only to collect student' answer but also to display the histogram of students' answers.

With the 'Classtalk', students are able to work collaboratively to clarify their understanding of the physics materials (which is also fit the existing learning theories mentioned in section 1.2.2). Moreover, students were engaged in active learning and more interactive in classroom. Equally important, students were positive about 'Classtalk' and believed that they had learn more than they had in traditional lecture. Besides, teacher devoted less time to lecture in classroom, while the students devoted more time in classroom to develop their knowledge for physics. The role of teacher was more to a coach than an information giver (Dufresne et al., 1996).

- (3) Situated learning: Chen, Kao, Yu and Sheu described a mobile butterfly-watching learning (BWL) system. In this system, each individual learner had a PDA which equipped with wireless network card and a small-sized camera. During the field trip to watch butterfly, a teacher carried a notebook computer with a WiFi wireless LAN card served as a local server. And more, this notebook computer had a complete butterfly database. Each learner took a picture of a butterfly and the picture would be sent to the database via wireless network. A content-based butterfly-image retrieval technique was applied in the system and search for the most closely matching butterfly to the picture sent and its information. Then, this information

returned to the learner. To evaluate this BWL system, the control groups used a butterfly guide textbook and the experimental groups used the BWL system to learn the key features of butterflies in elementary school in Taiwan. The results showed that the experimental groups were able to identify more key features of butterflies than control groups (Chen et al., 2004).

- (4) Collaborative learning: Cortez et al proposed a Mobile Computer Supported Collaborative Learning (MCSCCL) system which promoted students' collaborative learning without losing face-to-face contact. The system evaluation took place in high school physics class in Chile. In experimental groups, teacher taught the materials first and then applied the collaborative activity with the MCSCCL system to class. During the collaborative activity with the MCSCCL system, teacher downloaded the activity from website to pocket PC, and transmitted the activity to students' pocket PCs via MANET (mobile ad hoc network or mobile mesh network). Students were arranged in groups of three and worked together for the activity. When the activity finished, teacher could collect students' results from their pocket PCs into teacher's pocket PC, and then transmitted those results to computer and analyzed them. Cortez et al obtained statistically significant results showing that teaching and learning with the MCSCCL system enabled the students to construct new knowledge based upon the previous knowledge provided by teacher (Cortez et al., 2004).
- (5) Informal and lifelong learning: Wellington made differentiations of informal science learning and formal science learning as Table 1 (Wellington, 1990).

Table 1: The Features of Informal and Informal Science Learning.

Informal Science Learning	Formal Science Learning
Voluntary	Compulsory
Haphazard, unstructured, unsequenced	Structured, sequenced
Non-assessed, non-certified	Assessed, certified
Open-ended, learner-led, learner-centred	More closed, teacher-led, teacher-centred
Outside of formal settings	Classroom and institution-based
Unplanned	Planned
Many unintended outcomes (outcomes more difficult to measure)	Fewer unintended outcomes
Social aspect central, e.g. social interactions between visitors	Social aspect less central
Low 'currency'	High 'currency'
Undirected, not legislated for	Legislated and directed (controlled)

Here a practical example will be presented. The International centre of Digital Content at Liverpool John Moores University in United Kingdom proposed a PDA application for personal education of breast cancer patients (Wood, Keen, Basu, & Robertshaw, 2003). The functions of this application involved the delivery of text, images, videos, and those delivered information fit to individual patient's needs. Patients could also take notes within this application and discuss with doctor when they visited hospital. However, there is no evaluation of this personal education application so far.

- (6) Learning and teaching support: Corlett, Sharples, Bull and Chan described a 10-month trail of university students using a mobile learning organiser. The organiser was an mobile application which could install in students' mobile devices, and let students manager their their learning such as attending lectures, reading course contents, reciving for exams and meeting course dealines in this organiser. After the 10-month trail, they found out this

organiser was demanded for mobile learning especially for providing course content and timetable information (Corlett, Sharples, Bull, & Chan, 2005).

1.2.4. The Types of Mobile Learning

Mobile learning can be classified according to the number of learners and the location of learning activities. There were four types of mobile learning (Chang et al., 2003):

- Indoor individual mobile learning: the mobile device is used by one learner and the environment is indoor environment. Learner uses mobile device to acquire learning content or contact with teacher and peers. One example of the indoor individual mobile learning is museum's guiding system. The guiding system plays the role of teacher. When a visitor gets close to an exhibit, the mobile device receives the signal and it will display the relevant information of the exhibit. Visitor can understand more about the exhibit.
- Outdoor individual mobile learning: the mobile device is used by one learner and the environment is outdoor environment. This type of mobile learning make learner acquires information and interacts with authentic environment simultaneously.
- Indoor group mobile learning: in the classroom, every learner has a mobile device, communication infrastructure and the application which was designed for learning activities. Teacher uses an electronic whiteboard or other device as the instructional equipment. Teacher can send learning content, post questions, assign learning task, and check learning progress. Mobile devices are used to meet the needs of learning activities.

- Outdoor group mobile learning: outdoor group mobile learning is similar to outdoor individual mobile learning, but the learners work in groups to complete learning tasks collaboratively.

The mobile learning do not exist alone, it complements an existing learning environment. Educator must understand the advantages and limitations of mobile learning and use them to appropriate learning environment (Motiwalla, 2007). Different types of mobile learning are applicable to different learning context. Teachers can devise a mobile learning activity in accordance with requirements for learning content.

1.3. Augmented Reality (AR)

1.3.1. The Definition and Features of AR

Milgram and Kishino provided a ‘Reality-Virtuality (RV) continuum’ idea to describe the augmented reality (AR) as shown in Figure 3. Augmented reality is in the mixed reality which is between real environment and virtual environment. What the user precept is more close to virtual is augmented virtuality (AV); in contrast, what the user precept is more close to real environment is augmented reality (AR) (Milgram, Takemura, Utsumi, & Kishino, 1995).

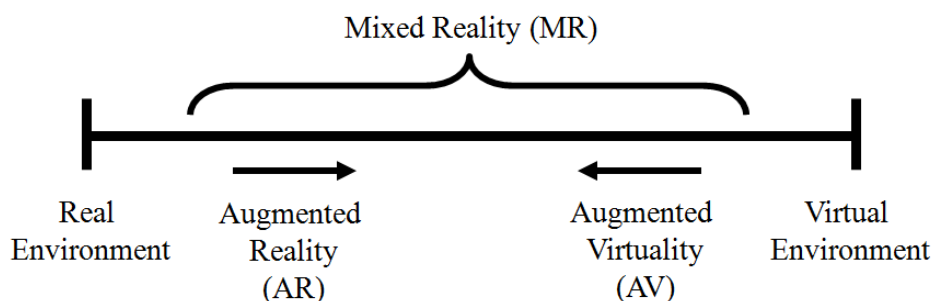


Figure 3: Milgram's Reality-Virtuality Continuum (Milgram et al., 1995).

Azuma gave a more easy-to-understand definition of augmented reality (Azuma, 1997). Azuma defined augmented reality is a variation of virtual reality. Virtual reality completely immerses the user in a virtual environment; that means users cannot see the real world around him/her and what he/she sees are virtual. However, augmented reality allows users to see the virtual objects within the real world. Some research also defined that augmented reality requires the head-mounted displays (HMDs), actually not all the application examples of augmented reality need the head-mounted displays. So, Azuma re-defined that augmented reality has three characteristics:

- combines real and virtual,
- is interactive in real time, and
- is registered in three dimensions.

Augmented reality is to enhance the users' perception and interaction with the real world through a virtual objects or environment in real time.

Recent advances in hardware (mobile device, wireless network) and software (applications) for mobile technology enable the development of mobile augmented reality (mobile AR) and its application. Papagiannakis, Singh and Magnenat-Thalmann defined the properties of mobile augmented reality as following (Papagiannakis, Singh, & Magnenat-Thalmann, 2008):

- combines real and virtual objects in a real environment,
- runs in real-time and mobile mode,
- registers (aligns) real and virtual objects with each other, and
- the virtual augmentation is based on dynamic, three dimensional objects (e.g. interactive, deformable virtual characters).

According the properties above, the necessary components of mobile augmented reality are (a) hardware computational platform, (b) display, (c) tracking, (d) wireless network,

(e) wearable input and interaction and (f) software. Moreover, to develop the mobile augmented reality technology, three technologies are considered to be important as well:

- mobile computational platform devices,
- augmented reality system architecture and content, and
- wireless networking.

1.3.2. The Display Modes of AR

In section 1.3.1, not all the application examples of augmented reality require head-mounted displays was mentioned. Here in this section, the display modes of augmented reality is presented. According to Bimber and Raskar's report in 2005, the display modes of augmented reality were categorized into several types (Bimber & Raskar, 2005).

- Head-attached displays: These kinds of displays require the users to wear the display system on the head. It includes
 - retinal displays,
 - head-mounted displays, and
 - head-mounted projective displays.
- Hand-held displays: The conventional examples of hand-held displays are Tablet PCs, PDA, cell phone and Smartphone. It also divided into two types:
 - video see-through hand-held displays, and
 - optical see-through hand-held displays.
- Spatial displays: These kinds of displays are different from body-attached displays (head-attached, hand-held). It also includes three subtypes:
 - screen-based video see-through displays,
 - spatial optical see-through displays, and

- projective-based spatial displays.

There are three ways to conduct augmented reality: marker-based, markerless, and gesture-based. Most applications of augmented reality now are using marker-based recognition technology.

1.3.3. The Examples in Science Education of AR

Billinghurst's Magic Book was first application to use augmented reality in education. People could read the book without any technology like how we read as usual. However, people could also read the book with the display system. When people read the page with display system, they saw three-dimensional models pop up on the page. The book with the augmented reality technology is an enhanced version of traditional 3-D pop up book (Billinghurst, Kato, & Poupyrev, 2001). In Liao's article, some applications of augmented reality in science education were reviewed. Here, three examples of chemistry, biology and outdoor nature science of the application of augmented reality chosen from Liao's article are presented (Liao, 2010).

Fjeld and Voegtli had reported a system benefited chemistry education called augmented chemistry. With the augmented chemistry, users can use the display system to look at the booklet. There were elements on the booklet. Users who are having a display system look at the booklet, the ball-stick 3-D model of the element would show up (Fjeld & Voegtli, 2002).

Juan, Beatrice and Cano described a system which used augmented reality for learning the interior of human body as shown in Figure 4. To evaluate this system, the children of the Summer School of the Technical University of Valencia participated in. The control group used a monitor as the visualization system and the keyboard to interact with the system while the experimental group used the head-mounted display as

the visualization system and the tangible interface to interact with the system. The results showed that there was not a statistical significant difference between the control and experimental group. But participants considered the system was useful for learning the interior of human body and even for other subjects (Juan, Beatrice, & Cano, 2008).



Figure 4: Juan's AR Human Body System (Juan et al., 2008).

The last example is outdoor natural science learning. Liu, Tan, and Chu reported their mobile learning system with augmented reality and RFID (radio frequency identification) technology as shown in Figure 5. To evaluate this system, elementary school students in Taiwan were participated. The learning setting was in a nature park in Taiwan, students carried a PDA to explore the park (Figure 5(A)). They used a RFID reader on the PDA to sensor the RFID tag on the information board (Figure 5(B)). The identification code of RFID code was transmitted to the server, and then the relevant information returned to the students' PDA (Figure 5(C)). After students finished the exploration in the park, they received a test. The results showed that the mobile outdoor learning improved students' learning and were able to attract students' interest in learning (Liu, Tan, & Chu, 2009).

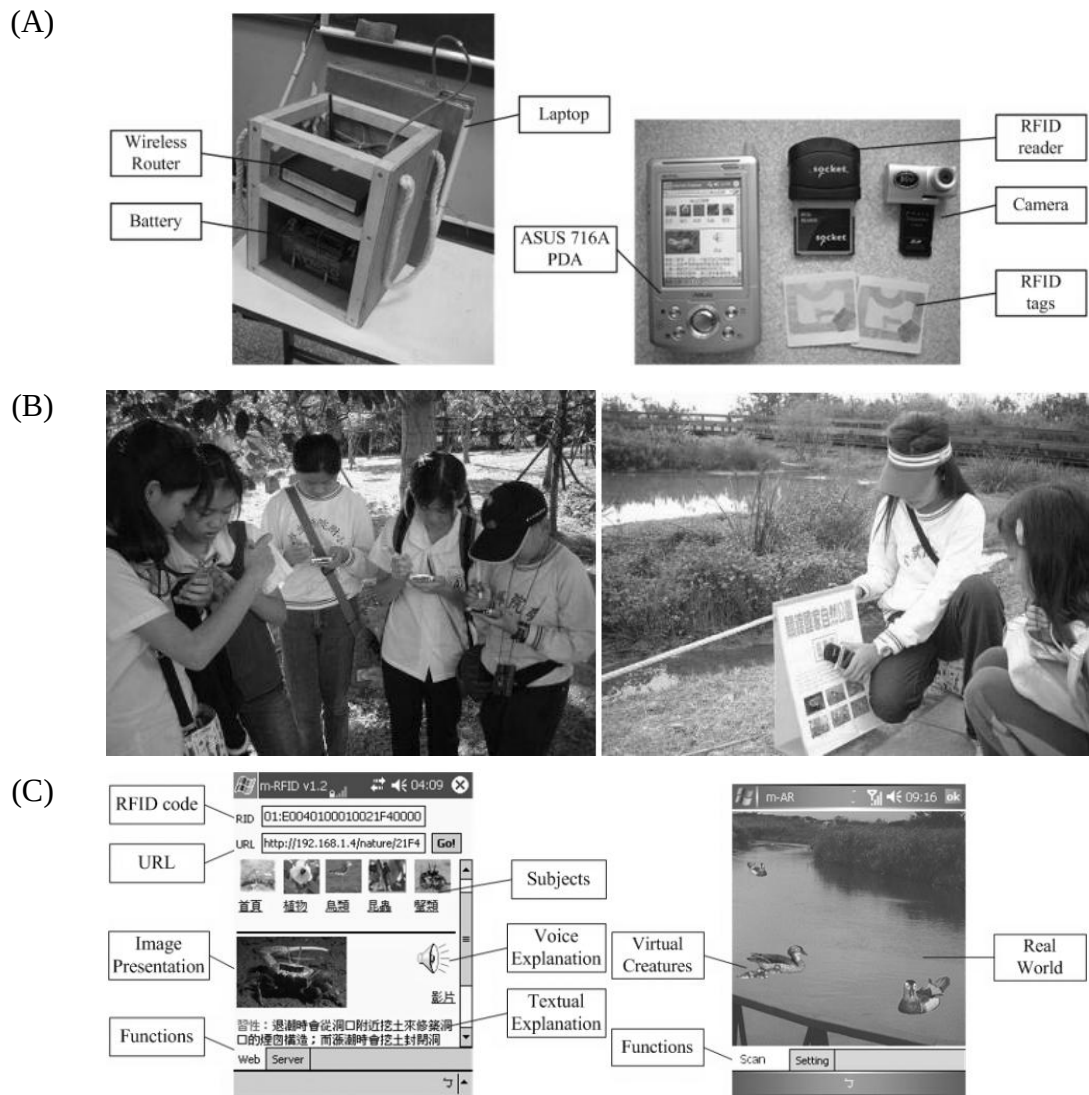


Figure 5: Outdoor Natural Science Learning with AR (Liu et al., 2009).

(A) The equipments of mobile outdoor natural science learning with AR technology

(B) Photographs of the outdoor learning activity.

(C) Screenshots of the interface of the mobile device with AR technology.

1.4. Research Purpose

Since mobile technology and wireless technology became flourishing, educators found the possibilities of mobile learning. Many researchers used PDA as mobile device and investigated whether it have an advantage over learning or not (Chen et al., 2003; Chen et al., 2004; Liu et al., 2009). At present, Smartphone and Tablet PC are more popular than PDA. One out of every two Taiwanese own a Smartphone from the report

of Google and Ipsos MediaCT. Students do not spend additional effort to adapt Smartphone and Tablet PC. Also, students can access to learning content outside the classroom and keep on learning after school through Smartphone and Tablet PC. The potentiality of using Smartphone and Tablet PC in education cannot be ignored.

Previous researches have shown The PDA effectively enhance learning (Chen et al., 2003; Chen et al., 2004; Liu et al., 2009). Whether Smartphone and Tablet PC have the same positive effects or not will be investigated in this research. The aims of this research were :

- (1) to develop a dual-purpose application of NTNU campus guide and science education which called NTNU campus tour application;
- (2) to design a outdoor mobile learning activity called NTNU campus tour activity which tied in NTNU campus tour application;
- (3) to investigate whether students' learning benefited from the mobile devices through NTNU campus tour activity or not;
- (4) to survey students' attitudes toward mobile learning.

2. Methodology

2.1. Research Process

The overall process of this research is shown in Figure 6, and in following sections, the research subject, the research instruments and the analysis method will be described in detail.

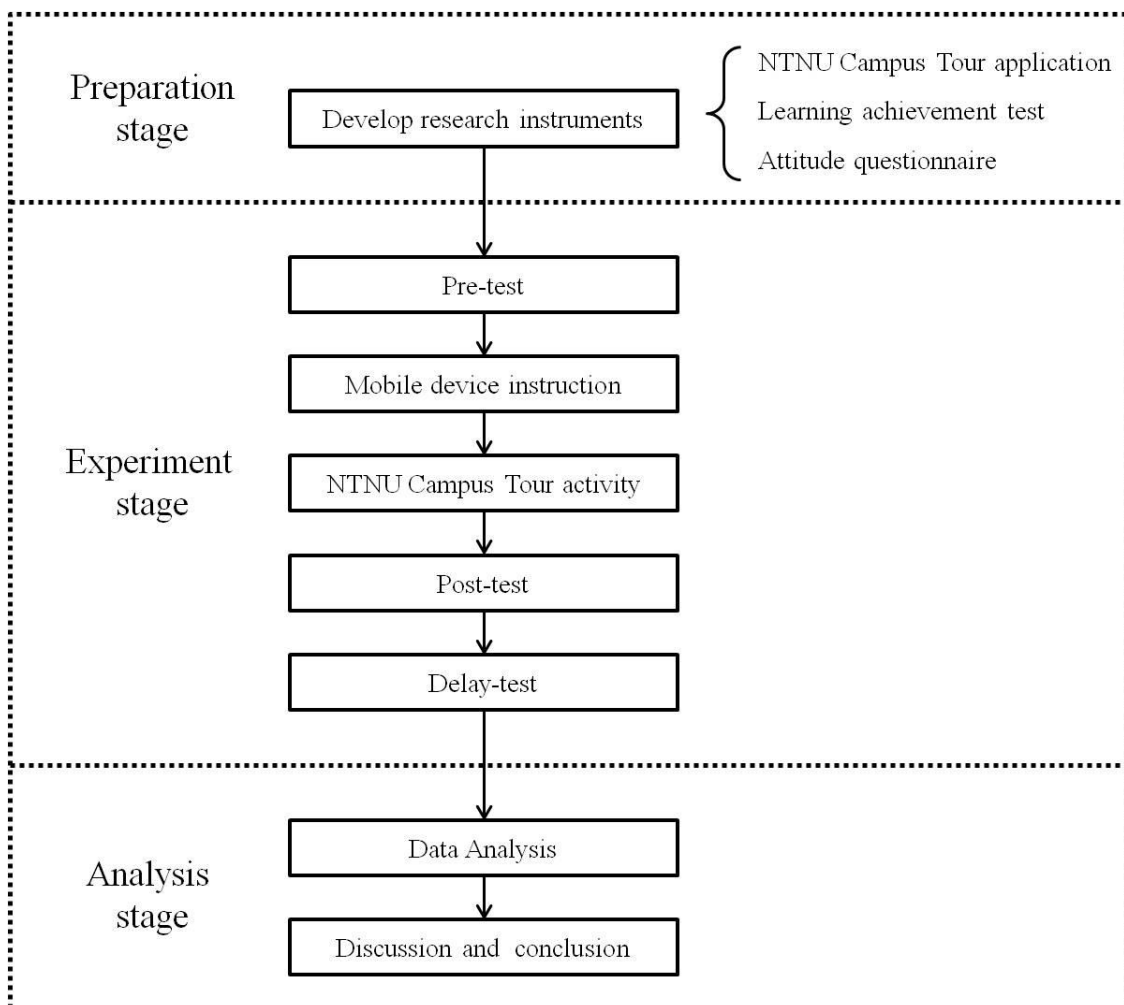


Figure 6: The Flowchart of Research Process.

In preparation stage, the NTNU Campus Tour application was developed with a dual purpose of NTNU campus guide as well as outdoor mobile science education. The

dual purpose of guide and education application was developed as a challenge game (which is called NTNU Campus Tour activity in Figure 6 and in following sections), and NTNU Gongguan campus was chosen as the game setting. The main buildings or landmarks in NTNU Gongguan campus were chosen as the challenge station and in each station one target item was chosen as a scientific learning material. Correspondent scientific knowledge and challenge activity to each target item were also provided. To evaluate this application, a learning achievement test as well as an attitude questionnaire was also developed; the details of these two tests are described in section 2.3.1.

In experimental stage, students first received a pre-test and orientation for the NTNU Campus Tour activity. Then students were arranged into groups of six, totally five groups. Each student carried one iPod to run NTNU Campus Tour application and other functions, and every group had one iPad for group discussion. Then started to experience this activity. During the whole activity, students were told to use the functions of the iPod and iPad. It cost about two hours to complete the activity. After finishing the NTNU Campus Tour activity, students immediately took a post-test and an attitude questionnaire. Seven weeks later, students took the delay-test.

Finally in analysis stage, all the data collected were analyzed via statically tests to prove whether the NTNU Campus Tour application with dual purpose of campus guide and science education benefit to students.

2.2. Research Subject

The subjects in this research are undergraduate students who are pre-service teachers in Taiwan. There are totally 31 students participated in this research, 14 males (45%) and 17 females (55%). But one of them are absent in delay-test.

The habit of using mobile devices of participant students is summarized in Table 2.

There are 27 students own mobile devices (74%) and 21 of them are used to using wireless network (68%).

Table 2: The Habit of Using Mobile Device of Participants.

	Gender		Own Mobile Devices		Use Wireless Network
Male	14 (45%)	Yes	23 (74%)	Yes	21 (68%)
Female	17 (55%)	No	8 (26%)	No	10 (32%)
Total: 31					

2.3. Research Instrument

2.3.1. Paper Tests

In this research, two paper tests were developed to evaluate the the NTNU Campus Tour application and the NTNU Campus Tour activity:

(1) Learning Achievement Test

This test was developed to evaluate participant students' learning achievement. There were ten multiple-choice questions in the test. All the questions were designed according to the scientific knowledge and challenge activity provided in the NTNU Campus Tour activity. The test questions were examined by experts who were docters in science education.

Pre-test, post-test, and delay-test were the same questions, but the orders of the questions and the option were changed. The learning achievement test is attached in Appendix I: The Learning Achievement Test.

(2) Attitude Questionnaire

Attitude questionnaire was used to gather the agreement on whether participant students consider the NTNU Campus Tour application benefit their leaning by five-point Likert scale and the advice to this application by

open-ended questions. The attitude questionnaire is attached in Appendix II.

2.3.2. NTNU Campus Tour Application

NTNU Campus Tour application is a dual-purpose application of NTNU campus guide and science education. This application is published in Apple APP store for free.

In this section, the basic functions in this application are introduced first:

- (1) Map: Map shows the location of five challenge stations, position the participant students' location, and guide the direction when students needed by GPS (global positioning system) as shown in Figure 7(A).
- (2) Guide: Guide which is shown in Figure 7(B) shows all five challenge stations in this activity and it contained introductions of the five stations in the National Taiwan Normal University Gongguan campus.
- (3) Recognition: The marker-based augmented reality technology was applied in this function. There was one target item in each challenge station, participant students should find out the target item (the marker in augmented reality technology) and use the recognition function to recognize it. After successful recognition, the correspondent scientific knowledge of the target item would showup and the activity was able to go on. The recognition time was about 10-30 seconds. It is shown in Figure 7(C).
- (4) Record: After successful recognition, the participant students won a prize as a pass certification as in Figure 7(D), and also their challenge history would be record here. Besides,the prize recorded the scientific knowledge which was already acquired. Students could review the scientific knowledge at any time and any place. They do not need to go back and to recognize the target item again.

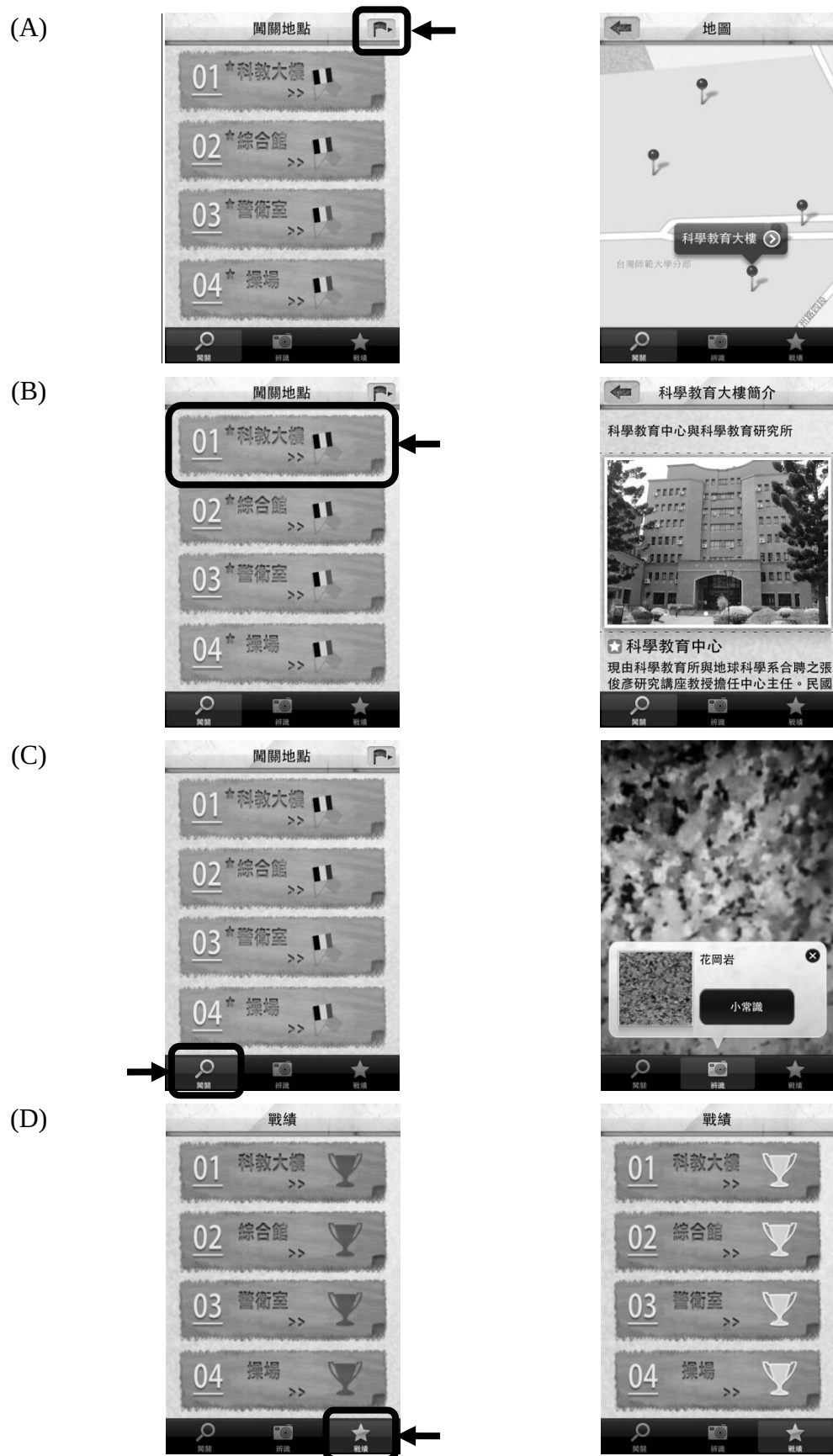


Figure 7: The Functions of NTNU Campus Tour Application.

One important function in this application should be described in detail is the recognition function which augmented reality technology applied in. In each challenge station (Figure 8(A)) there was one target item (the marker in the augmented reality technology) chosen by researcher should be recognized by the recognition function of this application Figure 8(B). After successful recognition, the scientific knowledge of the target item would show up as shown in Figure 8(C), (D) and (E), the information were scientific knowledge of the target item. Participant students should read the scientific knowledge and do the accompanied challenge activity. All steps above finished, participant students win a prize as a pass certification like Figure 8(F).

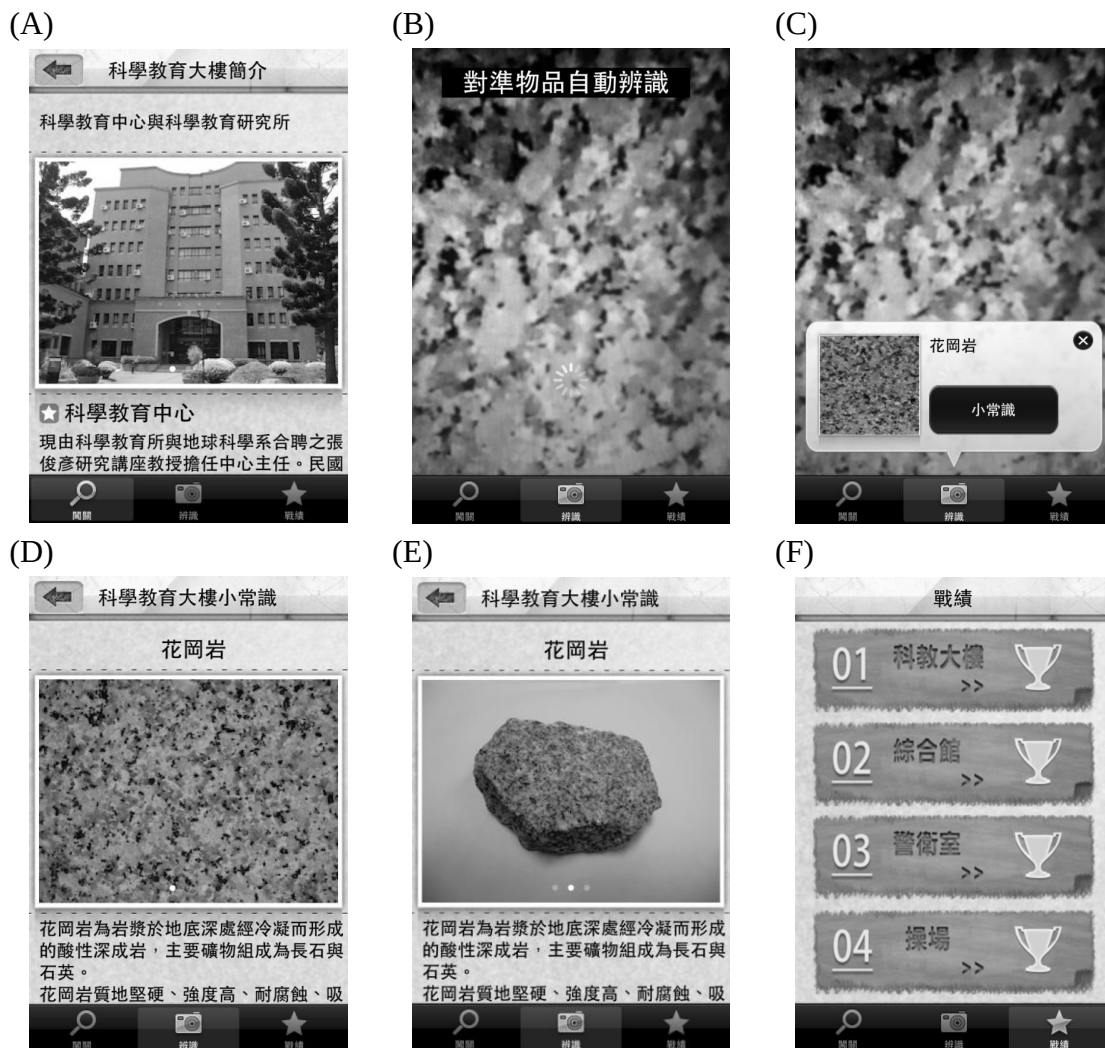


Figure 8: The Recognition Process of NTNU Campus Tour Application.

This recognition process is shown in Figure 9. Participant students use a mobile device with wireless network and already downloaded the NUTN Campus Tour application. The GPS will position participant students' location. Students in this activity use camera of the mobile device to recognize the target item, after recognized, the picture would be sent to database and then the matching information returned to the students.

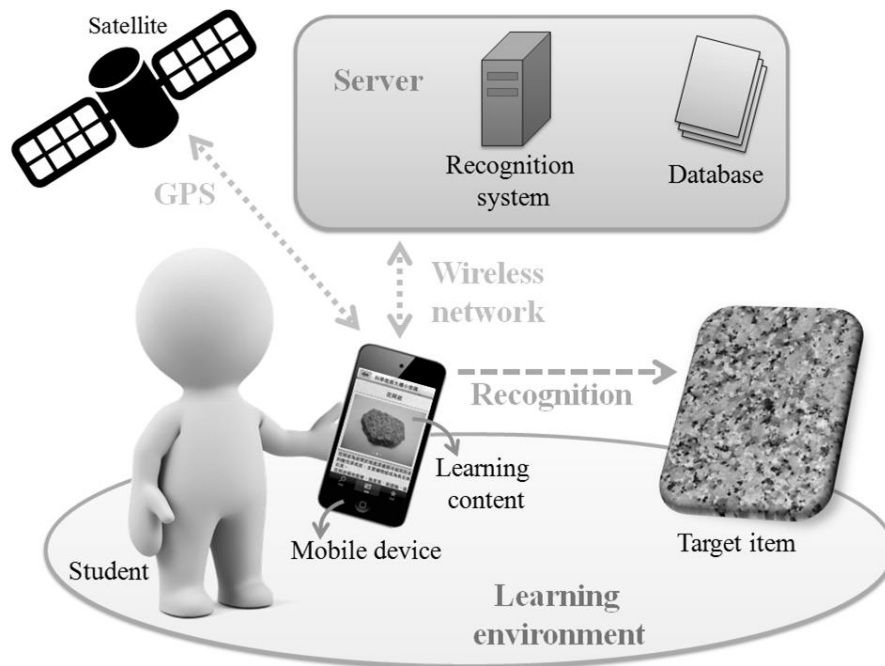


Figure 9: The Mobile Learning environment in This Research.

2.3.3. NTNU Campus Tour Activity

After participant students received the pre-test and the orientation for the NTNU Campus Tour activity (Figure 11(A)), students were randomly arranged into groups of six, totally five groups. Each student carried an iPod which was already equipped with the NTNU Campus Tour application downloaded from Apple APP store as mobile

device as well as each group also had one iPad for group discussion. There were five challenge stations in the activity, each group started from different stations and kept going on in orders shown in Figure 10. Students found the location of their challenge station via GPS. Arrived at the challenge station, they first read the information about the building or landmark of this station (Figure 11(B)), and then they had to find out the target item to recognize (Figure 11(C)). After successfully recognized the target item, the scientific knowledge pop up, students should carefully read it and obtain the knowledge (Figure 11(D)).

Besides, there was one instructor in each station. All the instructors were graduate students from the Graduate Institute of Science Education in National Taiwan Normal University. Instructors were requested to stay at each challenge station and assist students in finding out the target item as well as accomplished challenge activity (Appendix III). After students read the pop-up scientific knowledge of the target item, the instructor notified students of the challenge activity. When students successfully complete the activity (Figure 11(E)), they won a prize and record in main picture in the application (Figure 11(F)). Then, students could move to next challenge station to complete the whole activity.

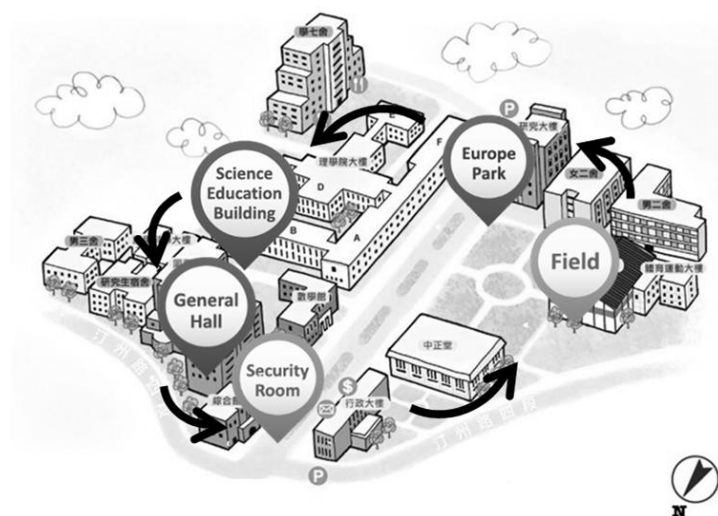


Figure 10: The Order of Five Challenge Stations.

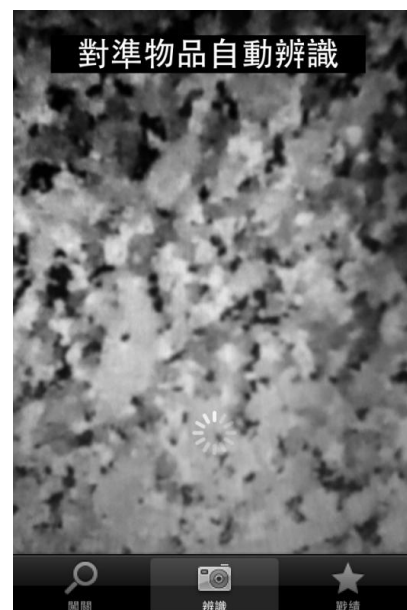
(A)



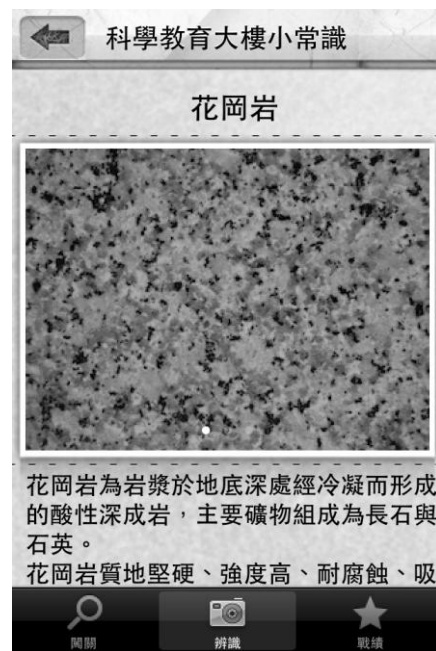
(B)



(C)



(D)



(E)



(F)



Figure 11: The process of the Activity in One Challenge Station.

There were five challenge stations in the NTNU Campus Tour activity. Each challenge station had one target item, and each target item accompanied scientific knowledge and one challenge activity. Here the five challenge stations, target items, scientific knowledge, and challenge activities are described in detail in the following text and also summarized in Table 3:

(1) Science Education Building

- Challenge station (building/landmark): Science Education Building.
- Campus guide: The introduction of the Graduate Institute of science Education. (Appendix IV)
- Target item: Granite.
- Scientific knowledge: The knowledge of granite. (Appendix V)
- Challenge activity: Students should drop some waters on the burnished granite, non-burnished granite and brick to observe the permeability.
- Learning objectives: Students are able to describe one feature of the granite and the reason that granite is a good architecture material.
- Teaching objectives: Let students understand the definition of permeability and are able to recognize the permeability feature which is a good architecture material of granite via the permeability experiment.

(2) General Hall

- Challenge station (building/landmark): General Hall.
- Campus guide: The introduction of the demonstration of rainwater harvesting and recycling system. (Appendix VI)
- Target item: Hoop Pine.
- Scientific knowledge: The knowledge of Hoop Pine. (Appendix VII)

- Challenge activity: Students should observe the shape of Hoop Pine seed and deduce the way how the seed dispersal.
- Learning objectives: Students are able to list the characteristics of Hoop Pine seed and describe the way how the Hoop Pine seed dispersal.
- Teaching objectives: Let students observe the shape of Hope Pine seed and understand the way how the seed dispersal by searching the information via wireless network on the mobile device.

(3) Security Room

- Challenge station (building/landmark): Security Room.
- Campus guide: The introduction of National Taiwan Normal University. (Appendix VIII)
- Target item: Brick tile.
- Scientific knowledge: The knowledge of the brick tile. (Appendix IX)
- Challenge activity: Students should discuss the differentiations of natural and man-made architecture materials.
- Learning objectives: Students are able to list the features of natural and man-made architecture material and differentiate them.
- Teaching objectives: Let students express their viewpoints of this topic after they searched the information via Internet and had a group discussion (collaborative learning).

(4) Field and Track

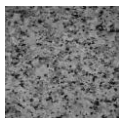
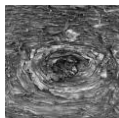
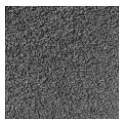
- Challenge station (building/landmark): Field and Track.
- Campus guide: The introduction of the Department of Athletic Performance. (Appendix X)
- Target item: PU (polyurethane) track.

- Scientific knowledge: The knowledge of PU (polyurethane) track. (Appendix XI)
- Challenge activity: Students had a game here. They had to use three puzzle foam floor mats to move forward in a distance; in the process, students' feet could not leave the puzzle foam floor mats.
- Learning objectives: Students are able to solve problems via team work.
- Teaching objectives: Let students solve problems collaboratively by having a game.

(5) Europe Park

- Challenge station (building/landmark): Europe Park.
- Campus guide: The introduction of Europe Park. (Appendix XII)
- Target item: Serpentine.
- Scientific knowledge: The knowledge of serpentine. (Appendix XIII)
- Challenge activity: Students should take five pictures of different animals or plants in Europe Park.
- Learning objectives: Students are able to record when they are doing observation.
- Teaching objectives: Let students record their finding by operating the camera on the mobile device.

Table 3: The Contents of Each Challenge Station.

Station	Building/landmark	Guide	Target item	Scientific knowledge	Challenge activity
1	Science Education Building	The introduction of the Graduate Institute of Science Education	Granite 	The knowledge of granite	Permeability experiment
2	General Hall	The introduction of the demonstration of rainwater harvesting and recycling system	Hoop Pine 	The knowledge of Hoop Pine	The way how Hoop Pine seed dispersal (Internet search)
3	Security Room	The introduction of National Taiwan Normal University	Brick tile 	The knowledge of brick tile	Differentiate the natural and man-made architecture materials (group discussion)
4	Field and Track	The introduction of the Department of Athletic Performance	PU track 	The knowledge of PU (polyurethane) track	Group game (teamwork)
5	Europe Park	The introduction of Europe Park	Serpentine 	The knowledge of serpentine	Capture animals and plants

During the whole activity, each student carried one iPod and each group also had one iPad. Students are able to freely use any functions on the iPod and iPad such as take notes, take pictures, surf the Internet and so on. The screen of iPad is larger than iPod which is much easier for students doing group discussion. The whole process of the NTNU Campus Tour activity is shown in Figure 12.

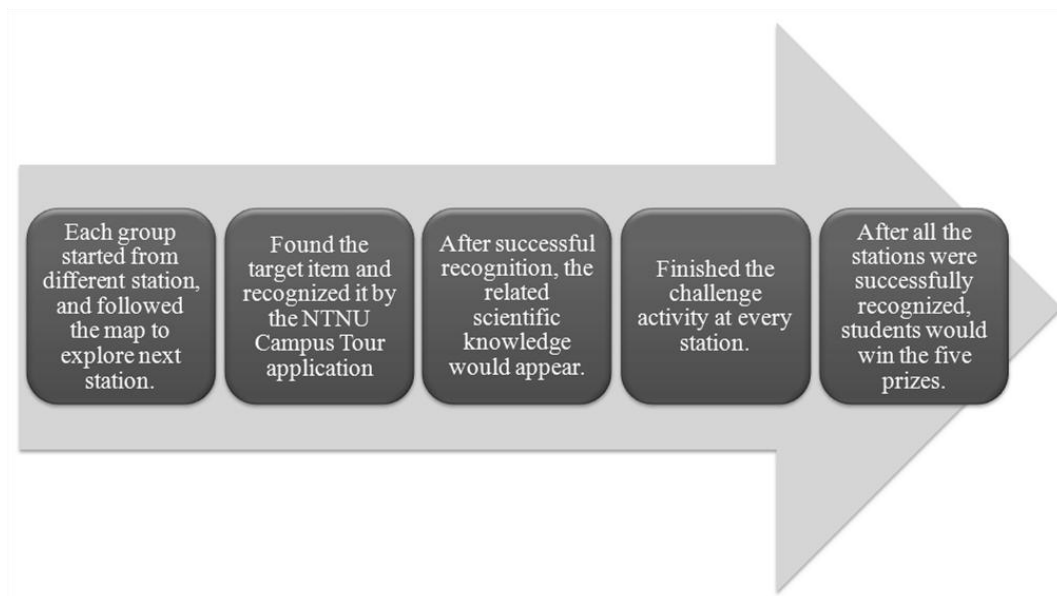


Figure 12: The Process of the NTNU Campus Tour activity.

2.4. Analytical Methods

Participant students took the pre-test (learning achievement test) before the NTNU Campus Tour activity, and received the post-test (learning achievement test) and attitude questionnaire test after experiencing the activity immediately. Seven weeks later, students returned to took the delay-test (learning achievement test).

The pre-test and the post-test were analyzed by paired samples t-test to examine whether students improve their knowledge after experiencing the NTNU Campus Tour activity. The pre-test and the delay test were also analyzed by paired samples t-test to

examine student's learning retentions.

Moreover, attitude questionnaire used five-point Likert scale. The largely agreement was given five points and the largely disagreement was given one point. The agreement of each question was presented as the mean to see the students' attitudes toward mobile learning.

3. Results

3.1. Learning Achievement Was Improved

Students took the learning achievement tests before and after experiencing the NTNU Campus Tour activity (which call pre-test and post-test respectively). Table 4 shows results of statistical analysis on learning achievement tests. The mean of pre-test was 6.16, and the standard deviation was 1.32. On the other hand, the mean of post-test was 9.32, and the standard deviation was 0.94. The score of post-test was significantly higher than the pre-test ($p < 0.001$, $d = 2.16$, a large effect size). That meaned after students experienced the NTNU Campus Tour activity, their performance in learning achievement test had improved.

Students did the delay-test seven weeks later; one student was absent. The mean of delay-test was 8.27, and the standard deviation was 1.51. The delay-test score was also significantly higher than the pre-test ($p < 0.001$, $d = 1.37$, a large effect size). It showed that the students remenbered the scientific knowledge learned from the NTNU Campus Tour activity.

Table 4: Results of Statistical Analysis on Learning Achievement Test

Pair	Test	N	Mean	SD	t	p	d
Pair 1	Pre-test	31	6.16	1.32	-12.03	.000	2.16
	Post-test	31	9.32	0.94			
Pair 2	Pre-test	30	6.20	1.32	-7.51	.000	1.37
	Delay-test	30	8.27	1.51			

3.2. NTNU Campus Tour App Helped Learning

After experiencing the NTNU Campus Tour activity with the NTNU Campus Tour

application, students took the attitude questionnaire test. The attitude was evaluated by five-point Likert scale; the largely agreement was given five points and the largely disagreement was given one point. The histogram shown in Figure 13 is the results of attitude questionnaire, and the agreement was the mean score from students.

As it shows in Figure 13, students considered that the NTNU Campus Tour application helped their learning. The mean score of students' agreement was 4.06.

3.3. Different Opinions on the Functions of Mobile Device

During the whole process of NTNU Campus Tour activity, students were allowed to use the functions of the mobile device completed challenge activity at every station such as taking notes, taking pictures, capturing picture and so on. Thus, students' tendencies toward those functions of mobile device in learning were also examined.

As shown in Figure 13, the functions of mobile device we examined were reading, completing assignments, taking notes, Internet searching, digital capture, and information exchange. The mean scores of students agreement were 4.16, 4.00, 3.50, 4.21, 4.21, and 4.11 respectively.

3.4. Students Were Willing to Use Mobile Learning

Participant students experienced mobile learning through NTNU Campus Tour activity. In attitude questionnaire test, students were asked their willingness to learn through mobile technology in the future. The mean scores of students agreement on mobile learning was 4.27. Students were willing to use mobile learning.

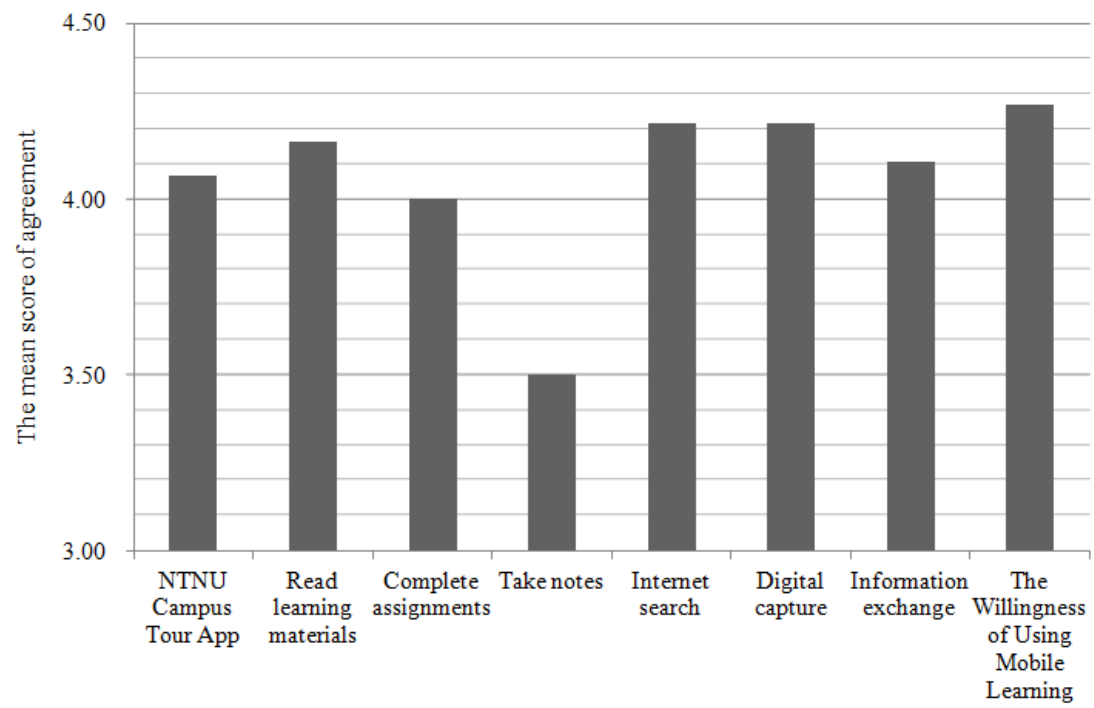


Figure 13: The results of attitude questionnaire.

4. Discussion

In this research, a dual-purpose application of NTNU campus guide and science education which was called NTNU Campus Tour application and an outdoor mobile learning activity were developed. Participant students were pre-service teachers and totally 31 participants in this research. After experiencing the NTNU Campus Tour application and activity, participant students' learning achievements of scientific knowledge which included in the application and activity had improved. Besides, participant students agreed that this NTNU Campus Tour application and activity was useful in learning and they will be willing to use mobile learning.

According to the results, students considered that the NTNU Campus Tour application helped their learning. The NTNU Campus Tour application had four functions: (1) Map, (2) Guide, (3) Recognition and (4) Record. Those functions played different roles in the outdoor mobile learning activity. The map function helped users to find out the location of stations in NTNU Campus, and the guide function introduced NTNU to users. Participant students in this research were NTNU students; they did not need to find the stations by using the map function and the guide function. The practicabilities of map and guide were not apparent in this research. But this does not mean that the map is useless. When students explore a new environment, the map and guide are essential. The recognition function provided students with the scientific knowledge. AR technology was applied in this function. After students successfully recognized target item (the marker in the AR technology), the scientific knowledge of the target item would show up. From the open-ended questions in questionnaire, students felt that it was an innovative, interesting and convenience way to obtain scientific knowledge. AR used in mobile device has opened a new door in information

achievement (Johnson & Witchey, 2011). The record function exhibited pass certification and recorded the scientific knowledge. From the questionnaire, some participant students replied that they extremely wanted to collect all the pass certifications. Pass certifications which act as reinforcement might increase students' learning motivation. In brief, participant students considered that the NTNU Campus Tour application helped their learning.

During the NTNU Campus Tour activity, students utilized the functions of mobile device to complete challenge activity at every station such as taking notes, taking pictures, capturing picture and so on. Whether those functions were helpful in learning or not were estimated by participant students. Students considered that internet search and digital capture were the most helpful functions in learning. They both got 4.21 point of mean scores of students agreement. It conformed to the urgency of learning need and the initiative of knowledge acquisition (Chen et al., 2003). At present, there is a lot of information on the Internet, people are getting used to surf the Internet to obtain useful information. Digital capture was also a benefic function for students. In the past, taking a picture needed to carry out many steps, such as develop films. Today, digital camera enables people to check the photographs on the display right away after pressing the shutter release button and allow us to send photographs to cyberspace. Also, image resolution becomes much higher with the advanced with display technology. Students can record what they saw more real and check the pictures in more convenient way than before. In the NTNU Campus Tour activity, students used the digital capture to record their experiment results. Participant students thought digital capture was helpful in learning because they could record experiment results by one shoot and did not have to spend much time on writing or painting. On the contrary, students held the lowest agreement with take notes which was 3.50 points of mean scores of students agreement.

From questionnaire, many students referred that the buttons of iPod were too small to press, and they needed to spend a lot of time on taking notes. Sound recording function and screen capture function are common in the mobile device. Those functions can be used to take notes and take the place of typing. Video and audio solve the problem of slow typing on mobile devices (Wang, Wu, & Wang, 2009). If students use video and audio functions to take notes or record something, it may be improve their will to take notes.

The NTNU Campus Tour activity developed in this research was an outdoor group mobile learning. There are still other types of mobile learning (Chang et al., 2003). Situating of instructional activity is one of the unique characteristics of mobile learning (Chen et al., 2003). To conform with the unique characteristic, the NTNU campus was chosen as outdoor learning environment, students used the NTNU Campus application to explore the campus environment and to learn the scientific knowledge. From the open-ended questions in questionnaire, students mentioned that even though scientific knowledge stated the appearance of hoop pine but it was too abstract for them. However in the NTNU Campus Tour activity, they actually saw the hoop pine, observed its height as well as the feature of its seeds, and speculated about the mode of seed dispersal in accordance with the feature of seeds. This kind of learning experience was interesting and close to real life. Students considered that they had profound impression on scientific knowledge because of their personal experience on seeing the authentic objects and observing the phenomenon. Learning environment is no longer restricted to classroom because of the mobility of mobile devices, learning occurs in everyday life (Shih, Chu, Hwang, & Kinshuk, 2011). Using mobile learning allows students to verify what they learned in authentic environment.

Overall, students used the NTNU Campus Tour application to explore the campus

and complete the activities at each station. In the process of experiencing mobile learning, students observed the real objects, interacted with peers, did experiments and accessed to scientific knowledge by recognition and AR technology. Students' performance in learning achievement test had significantly improved after experiencing the NTNU Campus Tour activity. Seven weeks later, students still remained learning retention. Students' learning benefited from the mobile learning. Besides, students were willing to use mobile learning in the future. To achieve the specific learning and teaching goals is needed to understand the advantages and disadvantages of one particular technology and at the same time to develop one appropriate learning activity (Motiwalla, 2007).

In this research, the NTNU Campus Tour application included the introductions of several sites in the Gongguan campus of National Taiwan Normal University. It was just a pilot application. Researchers hope that this dual purpose of NTNU campus guide as well as outdoor mobile science education application will be extended to all campuses of National Taiwan Normal University. Visitors or freshmen of NTNU are able to use the NTNU Campus Tour application to explore all campuses and also learn more scientific knowledge in the NTNU campus.

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Appendix

「大師闖師大」小常識測驗

各位同學，你好！這份測驗為「大師闖師大」App 小常識測驗，僅供學術研究使用，個人身分資訊將被保密，請放心填答。感謝您的協助，敬祝 學習愉快！

姓名：_____

- () 1. 蛇紋岩的外觀呈何種顏色？
A 深棕色 B 深黑色 C 灰白色 D 灰綠色
- () 2. 肯氏南洋杉的別名為何？
A 花旗杉 B 台灣杉 C 玉山杉 D 華南杉
- () 3. 磚瓦的原料為何？
A 石墨 B 矽砂 C 黏土 D 樹脂
- () 4. 花岡岩屬於下列何種岩石？
A 深成岩 B 噴出岩 C 變質岩 D 沉積岩
- () 5. PU 跑道的材質為何？
A 界面活性劑 B 乳化劑 C 高分子聚合物 D 碳水化合物
- () 6. 下列何者"非"花岡岩成為理想建材之特點？
A 擁有美麗的色澤 B 質地堅硬 C 耐腐蝕 D 吸水性高
- () 7. 蛇紋岩屬於下列何種岩石？
A 變質岩 B 深成岩 C 沈積岩 D 噴出岩
- () 8. 下列何者"非"磚瓦生產時必須經過的流程？
A 成形 B 練土 C 窯燒 D 上釉
- () 9. 下列何者"非"PU 跑道之特點？
A 無需整修 B 彈性優良 C 韌性強 D 耐磨
- () 10. 肯氏南洋杉種子的傳播方式為何？
A 利用彈力來傳播 B 利用風力來傳播
C 利用水力來傳播 D 利用動物來傳播

Appendix II: The Attitude Questionnaire

「大師闖師大」校園 App 行動學習體驗

各位同學，你好！這份問卷是關於行動學習之研究，你的學習經驗與想法將有助於了解行動學習之成效，以及未來行動學習之教學設計。這份問卷僅供學術研究使用，個人身分資訊將被保密，請放心填答。請提供你寶貴的意見給我們，感謝您的協助。敬祝 學習愉快！

姓名：_____

性別： ☐男 ☐女

請問你是否擁有行動裝置（ex.智慧型手機、iPod、iPad 等）呢？ ☐是 ☐否

請問你的行動裝置為何種作業系統？ ☐iOS ☐Android ☐其他

請問你平常有使用行動裝置上網的習慣嗎？ ☐是 ☐否

經歷過今天的行動學習體驗，針對下列各種學習活動，請回答下列問題。

	非常 不同 意	不 同 意	沒 意 見	同 意	非常 同 意
我覺得「大師闖師大」App 能幫助我學習。					
我覺得透過行動裝置閱讀學習素材能幫助我學習。					
我覺得透過行動裝置完成作業能幫助我學習。					
我覺得透過行動裝置做筆記能幫助我學習。					
我覺得透過行動裝置進行網路搜尋能幫助我學習。					
我覺得透過行動裝置記錄影像能幫助我學習。					
我覺得透過行動裝置交換資訊能幫助我學習。					
我將來願意使用今天所體驗的學習方式進行學習。					

下列題目為開放式的問答題，請盡可能的寫出你的想法：

1. 在今天科教大樓的關卡中，進行了花岡岩吸水性測試。你覺得這與過去你所經歷的學習方式有何不同？
2. 在今天綜合館的關卡中，實際觀察了肯氏南洋杉的種子，並推測其傳播方式。你覺得這與過去你所經歷的學習方式有何不同？

3. 在今天警衛室的關卡中，探討磚瓦為天然石材或人造石材。你覺得這與過去你所經歷的學習方式有何不同？
4. 在今天操場的關卡中，小組共同通過難關。你覺得這與過去你所經歷的學習方式有何不同？
5. 在今天科歐洲公園的關卡中，用影像記錄了你的所見所聞。你覺得這與過去你所經歷的學習方式有何不同？
6. 對於今天的行動學習體驗活動，你是否有任何感想或建議？
7. 如果你是老師，是否會使用今天所體驗到的學習活動來進行教學？為什麼？

Appendix III: The Instructor's Work

◆ 關主工作：

1. 學會使用行動裝置 (iPad、iPod)，活動期間提供給學生必要的協助，當學生對於行動裝置操作有問題時，給予幫助。
2. 說明關卡任務。必要時，協助學生完成任務。
3. 活動期間觀察學生的學習情形，以及活動流程是否有任何問題。

◆ 關主注意事項：

1. 關主須熟悉本活動所使用的行動裝置與軟體之操作。
(1) iPad (2) iPod (3) 大師闖師大
2. 關主須事先了解本研究與體驗活動之內容，並熟悉該關卡之活動與相關科學內容，才能給予學生正確的科學概念。

◆ 關卡說明：

關卡	辨識物	關卡任務	任務說明	關主工作	備註
科教大樓	花岡岩牆壁	花岡岩吸水性測試：做花岡岩吸水性測試，用滴管滴幾滴水於科教大樓拋光花岡岩、未拋光花岡岩及大樓前紅磚地，觀察水滴的吸收情形。	小常識中提及花岡岩吸水性低，故為好的建築材料，希望學生能親手做實驗驗證。	1.說明任務。 2.發放實驗器具。 3.協助學生將結果記錄於iPod 備忘錄中。	對於吸水性的定義，關主可做介紹。
綜合館	肯氏南洋杉	南洋杉種子的傳播方式：搜尋植物種子的傳播方式，並觀察肯氏南洋杉種子之外形，推測其傳播方式。	小常識中提及南洋杉的種子為毬果，且兩側具闊翅，希望學生能善用行動裝置上網搜尋資訊，並實際應用所習得的知識。	1.說明任務。 2.協助搜尋答案。	

關卡	辨識物	關卡任務	任務說明	關主工作	備註
警衛室	磚瓦牆壁	探討天然石材與人造石材之區別，磚瓦屬於人造或天然？	希望學生能善用行動裝置上網搜尋資訊，並且能夠進行小組討論。此題目無所謂"正確解答"，希望學生藉此了解在不同定義下，所產生的結果亦不相同，科學有時候亦是如此。	1.開啟任務說明。 2.協助學生將小組討論結果記錄於 iPad 備忘錄中。	
操場	PU 跑道	巧拼過河：全組利用三片巧拼向前移動，移動過程中雙腳不能離開巧拼。	希望學生在戶外活動的過程中，有機會動一動身體。	1.說明任務。 2.協助學生完成趣味接力。	
歐洲公園	蛇紋岩石椅	拍下歐洲公園中五種不同的植物或動物。	讓學生使用行動裝置之數位攝影功能，希望學生體驗到使用行動裝置能夠以不同於紙筆的方式記錄下所見所聞。	1.說明任務。 2.協助學生使用 iPod 攝影功能。	

科學教育大樓簡介



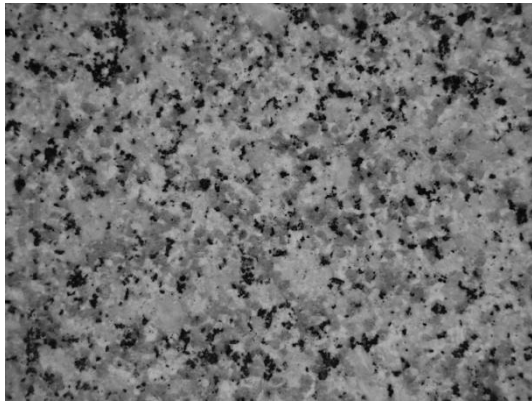
◆ 科學教育中心

現由科學教育所與地球科學系合聘之張俊彥研究講座教授擔任中心主任。民國 63 年 3 月，教育部為加強科學教育之研究實驗與推廣，指定本校成立科學教育中心，其成立宗旨為：(一)科學教育理論之研究，(二)科學課程之實驗與推廣，(三)科學教育資料之編譯與出版，(四)科學教具之研究與設計，(五)輔導科學教師之教學與在職進修。

◆ 科學教育研究所

現由許瑛珪教授擔任所長。科學教育研究所於民國 75 年成立，在教學上重視科學教育理論的紮根工作，也強調科學教育的實務演練。讓學生得以身處於科學教育的殿堂內學習知識、理論，也能經過教學實習、課程設計、多媒體製作教材等課程，獲得將理論推展至實務之經驗。

小常識---花岡岩



花岡岩是岩漿在地下深處經冷凝而形成的深成酸性火成岩，部分花岡岩為岩漿和沈積岩經變質而形成的岩類或混合岩化的岩石。

花岡岩質地堅硬緻密、強度高、抗風化、耐腐蝕、耐磨損、吸水性低，美麗的色澤還能保存百年以上，是建築的好材料，但它不耐熱。

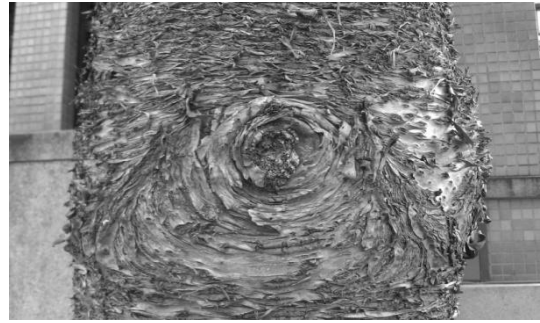
雨水回收示範系統



◆ 設置理念

基於珍惜水資源與永續校園理念，並落實綠色大學的承諾，設置雨水回收示範系統。將科教大樓及綜合館屋頂雨水收集處理並貯留，供周邊綠地澆灌，粗估可年省 3000 噸澆灌用水。

小常識---肯氏南洋杉



肯氏南洋杉，別名花旗杉，原產地澳洲，為南洋杉科常綠喬木。

外觀上，樹幹挺直，株高可達 30 公尺；樹皮有明顯剝落的現象，且為橫向剝落；枝極自然分層輪生於主幹四周，葉呈針狀密生，外貌彷彿雞毛撢子一般；雌雄異株，毬果呈卵圓形，果鱗呈寬楔形，前端銳尖而向外反捲，兩側均具闊翅。常作為庭園佈置與行道樹。

國立台灣師範大學



◆ 國立台灣師範大學

現任校長為張國恩博士。師大有三個校區：本部、公館及林口校區，目前所在的位置即為公館校區。本校轉型發展為綜合大學，以「古典人文風華，現代科技視野」為願景，培養各個領域中的菁英。目前擁有教育、文、理、藝術、科技、運動與休閒、國際與僑教、音樂、管理及社會科學等 10 個學院。

小常識——磚瓦



一般生產流程：



磚瓦的原料為黏土，黏土是由岩石經風化分解後形成的，可塑性高，加水於黏土中充當潤滑劑會使粒子間更容易滑動，使得黏土容易捏塑。成形後，放入窯中，高溫燒結而成。

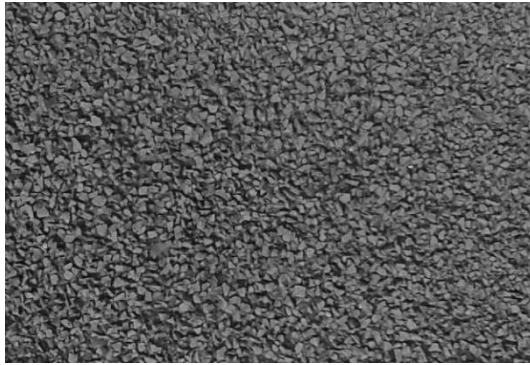
國立台灣師範大學運動競技系



◆ 運動與休閒學院

現任院長為張少熙博士。民國 90 年整合體育、運動與休閒三大領域，成立運動與休閒學院，為培育台灣國內體育高素質專才的搖籃，目前擁有體育學系所、運動競技學系、運動與休閒管理研究及運動科學研究所。師大培育出許優秀的人才，如盧彥勳(網球)、何筱珪(舉重)、鄭韶婕(羽球)、莊佳佳(跆拳道)等人。

小常識---PU 跑道



PU 跑道的材質為聚胺酯 (Poly Urethane, PU)，是主鏈中含有胺基甲酸酯特徵單元的高分子聚合物，因其具優良彈性、強韌性、耐磨等特性，相較於其他塑膠原料之製品，更能因應現代田徑運動場之需要。

歐洲公園



◆ 歐洲公園

位於公館校區中正堂旁，老榕樹在蒼翠蓊鬱的公園中心，被盛開的翠綠棕梠、綻放的金黃阿勃勒圍繞著。傳說只要在期中考經過這裡，考試就能「all pass」，因此又被稱為「all pass 公園」。公園中白色座椅為 66 級畢業生所贈，椅背上有「66」字樣。

◆ 師大校樹

阿勃勒，又稱波斯皂莢，原產於印度，為蘇木科落葉喬木，株高約 8-12 公尺，偶數羽狀複葉，小葉 4-8 對。1645 年由荷蘭人引進種植。阿勃勒為什麼是師大校樹，至今無法考據，有一種說法是，因為它的長莢果像極了舊時代教師手中的教鞭，從此成為師大校樹。

小常識---蛇紋岩



蛇紋岩是由橄欖岩，經區域變質作用或熱液交代作用，而形成的一種變質岩。蛇紋岩表面光滑且質軟，顏色一般為灰綠色、黑綠色或黃綠色，色澤不均勻，具美麗的紋彩，可作為工藝品原料或建築裝飾材料。在公園或其他地方常見到的石桌椅即是由蛇紋岩製成。蛇紋岩的石棉可作為耐火材料，亦可作為提煉鎂或鈣磷鎂肥的原料。其他礦物有磁鐵礦、鈦鐵礦、鉻鐵礦、菱鎂礦、滑石等。