The Application of QR Codes in Outdoor Education Activities: Practice and Discussion

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Abstract: We developed a mobile study program based on a cognitive theory of multimedia learning (CTML) and designed a novel outdoor mobile learning system (QR Code Information Greenmap, QRCIG). Learners use smart phones or similar devices equipped with decoding software to decode QR codes embedded in a Green Map that deliver images and voice assistance to learners about relevant content. We observed and measured 120 fifth and sixth grade elementary school students' outdoor activities and analysed the data by using the Technology Acceptance Model (TAM). The results demonstrated that students' behavioral intention to use and attitudes regarding the QRCIG were significantly positive (correlation coefficient = 0.597**). Moreover, according to the analysis, the greater the skill of the students in using the QR code was, the higher their behavioral intention to use and frequency of adoption were (correlation coefficient ranging from 0.341 to 0.852). By conducting analysis using the TAM, we proved that an education program integrated using wireless mobile devices and message image (QR code) is highly applicable in outdoor education.

Keywords：CTML, QR Code, Outdoor education, Green Map

1. Introduction

Using surrounding resources to educate students for multi-learning purposes is a popular outdoor education method today (Elma & Martin, 2010). The Green Map System has been developed collaboratively since 1995, and the system has been extended to more than 65 nations and 845 cities. In this system, simple icons are used to help people understand their surrounding environment and cities (http://www.greenmap.org/greenhouse/en /about). This system is effective for deploying local resources and provides an alternative channel to outdoor education. However, outdoor environments are more complex than classrooms are. Information technology is a valuable tool for students; therefore, integrating information technology with outdoor education activities is expected to be a future trend (Shavinina, 2009). The mobile learning pattern constructed in technology-based activities involves urgency in occasional learning, an initiative nature in knowledge acquisition, and flexibility in space. Hence, learners must initiate efforts to learn their surroundings by using ubiquitous resources to improve their learning efficiency. This pattern is suitable for facilitating lifelong learning and developing flexibility (Chen, Kao, & Sheu, 2003). Smart phones and tablets have great potential because millions of people use these devices. Moreover, these devices can be used extensively in behavioral investigation, testing, and experimentation (Miller, 2012). Because mobile learning devices have wireless connection capabilities, learning is mobile and can occur at any location, from classrooms to outdoors. Therefore, valuable information can be acquired at any location (Sharples, 2000). As a result, the purpose of this study was to develop an integrated system composed of QR codes, Green Maps (GMs), mobile kits, and wireless technology. By using the integrated system, students enjoyed audio-visual guidance outdoors, and educators maximised the positive effects of texts and materials.

1.1 Multi-learning styles in Outdoor Education: The application of Green Map

In the United Nations Decade of Education for Sustainable Development (2005-2014), UNESCO Education Sector (2005) indicated that many political authorities worldwide are aware of the value of educating citizens on sustainable development. These authorities ask their civil servants to teach climate change and related environmental issues in the school. They have held numerous conferences and seminars to train educators about the project. Therefore, it is expected that the environment can be preserved through implementation of these ideas in national policy and education curricula. In addition, through a project named Carbon School, the European Union (EU) connected scientists, teachers, and students and encouraged them to use obtainable resources in conducting research on climate change and its influence on the earth, and to take appropriate action (Elma & Martin, 2010). This type of inquiry and project-based learning method helped children engage in healthy interaction with the earth and develop correct perspectives about the environment. This method is expected to enable the next generation to be more fervent and innovative regarding environmental protection than the current generation is.

Outdoor education is an interdisciplinary activity comprising multiple interactions. Educators must focus on diversification, targeted content, and methodology. Teachers must have practical experience to become competent in understanding environmental parameters (Pleasants, 2007; Thorburn & Allison, 2010). Many studies have indicated that the effective practice of technology use can stimulate students' motivation, help them write notes, and enforce their independence in self-learning (Rogers et al., 2005; Chen, Kao, Yu, & Sheu, 2004). Moreover, the use of mobile devices can broaden students' experiences in outdoor education (Rogers et al., 2004; Squire & Jan, 2007). Outdoor education does not only involve improving knowledge, but also involves gaining experience through the process (Rickinson, 2001). Therefore, only when educators have a clear vision and teaching materials can they provide outstanding education (May, 2000). This is the main goal of educators today. They are expected to use new technologies for curriculum design and development.

Zuber (1999) and Green and Swanitz (1991) demonstrated that GMs are a suitable material for stimulating students' motivation to learn about green issues. A GM is a map that promotes nature, sustainability, and ecology (please refer to http://www.greenmap.org/greenhouse/files/gms/GreenMapIcon_V3_Chart.pdf). In a GM, the relationship between people and the environment is clearly marked and illustrated, which makes it an effective material for enabling inhabitants and students to engage in environmental exploration (Green Map Activity Guide, 2005). GMs are widely applied in outdoor education, and by the end of 2012, 842 registered Green Map projects were conducted in 68 nations (http://www.greenmap.org/greenhouse/en/node/12842). Therefore, we used GMs as teaching materials for outdoor education and embedded QR Codes into the program, thereby facilitating ubiquitous learning.

1.2 Design of M-learning on Environmental Education

Today, the development of GMs is nearly mature; therefore, students experience little difficulty in using and learning a GM in ordinary maps. We used this advantage to digitalize and apply QR codes to the map, enabling students receiving outdoor education to quickly identify links to information. This application is suited to the current educational goal of governments worldwide, which is to develop the ability of citizens who have basic skills in information technology use (Hiltz & Turoff, 2005; Lim & Kim, 2003). QR codes are two dimensional, the information capacity is 1,000 words, and images and signals can be contained without the limitations of sizes and colours. If the code image is damaged and the damaged area does not exceed 30% of the original image, then the information is retrievable. QR codes have been popular worldwide for years (Lai, Chang, Li, Fan, & Wu, 2012). Accordingly, we adopted a cognitive theory of multimedia learning (CTML) to integrate information into m-learning in outdoor education. Mayer (2001) stated that multimedia information designed based on a mental mechanism provides more meaningful messages to learners than multimedia messages that are not based on a mental mechanism do; therefore, if multimedia tools are involved in a responsive learning environment as a primary tool, then students' understanding is promoted. This wireless learning information system provides appropriate immediate learning at any location. People can use wireless devices equipped with a digital camera to decode QR codes and capture multimedia information at their present location. Quinn (2000) indicated that m-learning, which is defined as learning that occurs through mobile devices, is suitable for education in numerous places.

We used QR codes to design a service that facilitates learning that is not limited by space or time. Learners can access digital information and teaching materials and learn from this method. Asynchronous learning was (Chen et al., 2003) integrated with the Internet and QR codes, enabling learners to acquire necessary information in a short period of time asynchronically. As shown in Figure 1, digital content was linked through decoding and wireless connections and transferred to the mobile devices of learners.

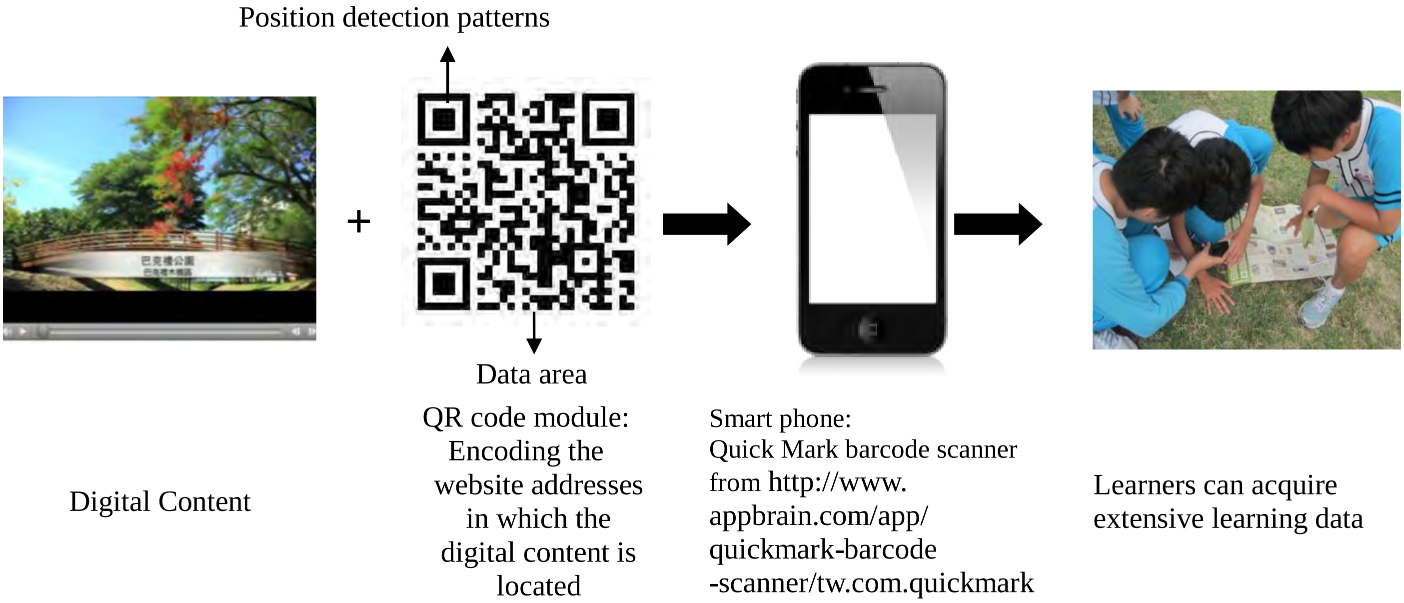

Figure 1. Digital content accessed using mobile devices facilitates achieving the goal of asynchronous learning

As shown in Figure 1, digital information is decoded and connected to the web server, and the existing information is subsequently presented to learners. The official QR code website indicated (http://www.qrcode.com/en/index.html) that the three squares around the four corners are designed to help decoders relocate; therefore, they do not need to scan it precisely. We used QR codes to design a service that is not limited by time or space, providing learners digital information and learning materials and helping them to acquire knowledge. Asynchronous m-learning (Chen et al., 2003) was integrated with the internet to enable users to access fruitful multimedia information. The process is quick and precise, and the acquisition is immediate.

The innovation involved in the present study is the integration of natural science and social science. Integrating a GM with QR codes improves it compared with the original text version. Furthermore, voice and animation were added to the scenic introduction and embedded in the digital platform. This system must be supported by a wireless network and a mobile device with a decoding function (Quick Mark barcode scanner, from http://www.appbrain.com/app/quickmark-barcode-scanner/tw.com.quickmark). When the device decodes a QR code, the service provides animation or voice guidance through the Internet. This service is called the QR Code Information Greenmap (QRCIG). The structure of the QRCIG is illustrated in Figure 2.

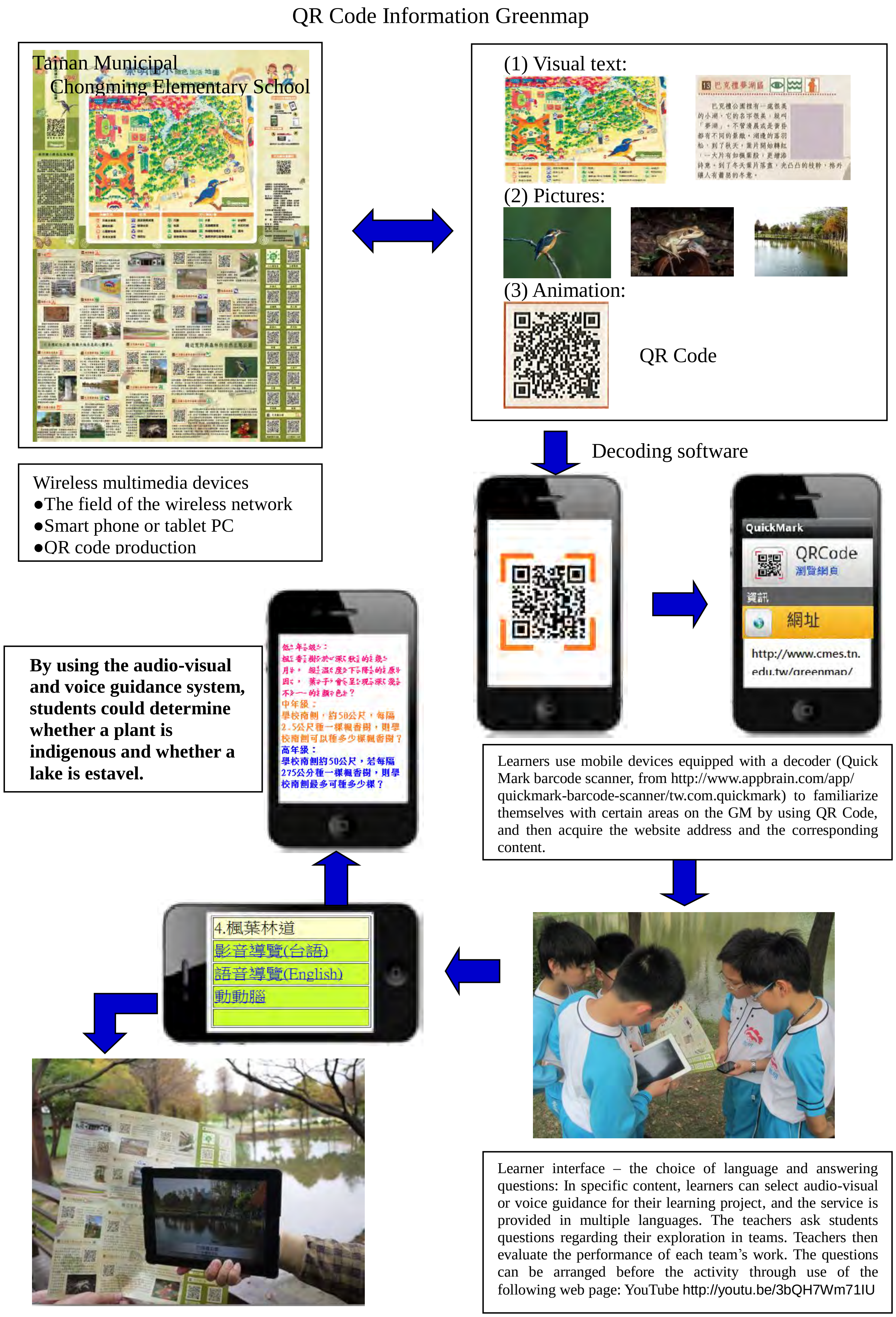

Figure 2. Integrated QR Code Learning System Architecture

Mayer (2001) and Mayer & Moreno (2002) stated that students acquire more information and achieve more positive learning goals when viewing animation presented using voice-overs than when viewing dubbed animation without voice-overs. Based on this previous study, we adopted the modality principle from the CTML to integrate text, images, and animation. The methodology is explained as follows:

A. Text: We used a universal icon system to signify ecological and cultural locations on the map. The locations were then verified by fieldworkers, and descriptions are presented together.
B. Image: Photographs captured during fieldwork are presented as a reference for users when they are reading the text.
C. Animation: Films captured during fieldwork are used to assist students in their learning, which is supplemented by oral explanation. The audio-visual guidance was linked using the QR code platform.

The procedure of the aforementioned system is introduced as follows:

A. School teachers, advisory professors, and association members from societies participated in the procedure, and then designed the system based on the majority's view point, producing a GM with icons.
B. We introduced icons in GM scenic spots by using audio-visual information, making them audio-visual materials.
C. We input the audio-visual materials into Multimedia U-learning platform server and assigned each datum corresponding QR codes.
D. We positioned the encoded QR codes at the corresponding locations on the GM.

The pre-study (Lai et al., 2012) showed that teachers positively evaluated the application of audio-visual guidance in presenting text, images, and voice functions simultaneously. In that study, the coefficient factor modulus between the ease of use and usefulness of the QR codes was 0.749**. This result demonstrates that the high ease of use of the QR code application triggered teachers' perception of the usefulness of the system, and the coefficient factor modulus between the usefulness of the QR code and people's acceptance of using QR codes was as high as 0.872**, which indicates a highly positive correlation between QR code usefulness and QR code acceptance. The analysis also demonstrated that teachers who were skilled at using QR codes tended to have higher behavioral intention to use and acceptance than those who were not. This indicates that QR codes can be accepted by teachers as a tool for use in outdoor education activities. Because the analysis of teachers' perceptions of the program were well conducted and the results proved to be positive, the present study focused on students in outdoor education.

2. **Methodology**

We adopted a TAM pattern to investigate behavioral intention to use towards using and acceptance of the method. The TAM is a tool developed by Davis (1989) based on behavioral theory (TRA) that is used for interpreting cognition and emotion parameters that affect the use of technology. TAM can be used to inspect people's inclination towards new technology. The pattern was developed to integrate the simplest methods of applying research theory and provides insight into personal exploration. Therefore, researchers can observe the factors affecting people's beliefs, attitudes, and intentions when they are using technology (Davis, Bagozzi, & Warshaw, 1989). Because of this advantage of easiness, we infer that the TAM pattern is the pattern adopted most frequently internationally when researchers are examining people's acceptance of technology (Davis, 1989; Venkatesh & Morris, 2000). Davis (1989) indicated that when users perceive accessing certain information to be simple, they tend to feel positive about the system. When users positively evaluate certain information regarding its cognitive usefulness, their positive attitude towards that information is higher. Furthermore, when users more highly evaluate the cognitive ease of use of certain information, they tend to more positively evaluate its cognitive usefulness.

We administered a questionnaire in which the answer is graded based on a 4-Point Likert scale. The content is divided into seven categories, namely, "personal information," "self-estimation of information accessibility," "preference investigation of the QRCIG and conventional GM," "ease of use of the QRCIG," "usefulness of the QRCIG," "attitude towards the QRCIG," and "behavioral intention to use regarding the QRCIG." The Cronbach's alpha value was 0.925, indicating that the questionnaire is highly reliable. The questionnaire was designed to investigate whether students understand that the function of QR codes could affect the application of the QRCIG in outdoor education and to evaluate the behavioral intention to use of users regarding the QR codes. The questionnaire was also designed to determine whether students perceive the QRCIG as easy to use (ease of use), which enables students to use the system to achieve learning goals and improve their knowledge acquisition (usefulness). Finally, the questionnaire assesses whether it can assist the design of the QRCIG and promote students' intention to use this system in the future, and analyses their adaption of it.

3. Results

This section presents the responses observed in the experiments under different investigations and the corresponding samples. The observations were meticulously analysed and explained. Among the 123 returned questionnaires, 120 copies were valid and 3 were invalid. The section contained three subsections for different explanations. In the first subsection, different backgrounds are used as parameters to discuss the ease of use and usefulness of, as well as the attitudes towards, the QRCIG. In the second subsection, students' preference for either the QRCIG or conventional Green Maps was used as the parameter to discuss differences in preference. In the third subsection, the correlations among information accessibility, ease of use, usefulness, and attitudes regarding the QRCIG were analysed.

3.1 Different backgrounds as the parameter for the discussion of ease of use, usefulness, and attitudes regarding the QRCIG

3.1.1 Descriptive statistics and t test results of the perceived ease of use and usefulness, and the attitudes regarding the QRCIG of students who used QR codes prior to the study

Table 1: Descriptive statistics and t test results of the perceived ease of use and usefulness, and the attitudes, of students who used QR codes prior to the study.

Category	Mean	Standard Deviation	*t* test
Ease of Use	18.30	2.30	1.936*
	17.26	2.50	
Usefulness	18.40	1.99	2.331*
	17.22	2.39	
Attitude	14.38	2.03	2.378*
	13.33	2.00	
Behavioural intention to use	14.33	2.04	1.812
	13.52	2.12	

$^{*}p < .05$

According to questionnaire analysis revealed there were 93 students had been read QR Code icon, it was over 1/4 of all samples. As shown in Table 1, whether students used QR code or related functions prior to the study is an important parameter that significantly affected the perceived ease of use and usefulness, as well as their attitudes, regarding the QRCIG. This indicates that QR code knowledge affects students' perceptions of the ease of use(*t* test =1.936*), usefulness(*t* test =2.331*), and attitudes(*t* test =2.378*) regarding the QRCIG.

3.2 Students' preference for either the QRCIG or conventional green maps as the parameter

Table 2: Frequency distribution of the preference of the QRCIG or conventional green maps.

Item	Which item do I prefer to acquire knowledge?	Which method do I prefer to reach the goal?	Which learning method is better for me?
QRCIG	115(95.8%)	116(96.7%)	111(92.5%)
Conventional Green Map	5(4.2%)	4(3.3%)	9(7.5%)

As shown in Table 2, students received both conventional Green Maps and the QRCIG as the learning methods used to reach the goal of outdoor education, and over 90% preferred the QRCIG as the method for their education. This demonstrates that the design of the QRCIG promotes students' intention to learn.

3.3 Correlations among information competence, ease of use, usefulness, and attitudes towards the QRCIG

Table 3: Comparison of information accessibility, ease of use, application, attitudes, and behavioral intention to use.

Category	Information Accessibility	Ease of Use	Usefulness	Behavioural Intention to Use
Ease of Use	0.361^{**}	--		
Usefulness	0.404^{**}	0.785^{**}	--	
Attitudes	0.341^{**}	0.641^{**}	0.611^{**}	--
Behavioural Intention to Use	0.405^{**}	0.757^{**}	0.712^{**}	0.852^{**}

$^{*}p < .05$, $^{**}p < .01$

As shown in Table 3, the Pearson correlation coefficients of students' information accessibility, ease of use, usefulness, attitudes, and behavioral intention to use were between 0.341 to 0.852, indicating that students are responsive to information accessibility, ease of use, usefulness, attitudes, and behavioral intention to use regarding QR codes at medium to high level.

4. Discussion

We introduced QR-coded learning to an outdoor education m-learning program. The project inspired curriculum design, methodology design, students' perception, and students to learn through various ways. These inspirations helped both teachers and students to practically explore the curriculum and interact positively with the environment. This contribution satisfies the goal of diversification in education. The present study is based on Mayer's proposal (2001) that voiced-over multimedia information is easier for students to understand than dubbed multimedia information is. In addition, we used the TAM for system analysis and found that students are interested in QR-coded mobile learning in outdoor education.

Lai et al. (2012) used QR codes in Green Maps based on the CTML and designed a multimedia learning system. Their results showed that teachers expressed highly positive attitudes towards applying the QRCIG in outdoor education. Therefore, to investigate the inclination of students to use this system in outdoor education, we used information accessibility of student as external variables in an analysis of fifth and sixth grade elementary students' questionnaire feedback after they participated in activities based on the TAM.

The present study demonstrated that, among two learning models, namely, the QRCIG and conventional green maps, more than 90% of the students preferred the QRCIG as the method for attaining the goal of outdoor education. In addition, the m-learning QRCIG was integrated with outdoor education and the parameters were students' backgrounds. "Whether students used QR codes or related function prior to the study" was the main parameter affecting ease of use, usefulness, and attitudes. This parameter is crucial for learning how to use the QRCIG for elementary school students. Moreover, ease of use (Pearson correlation coefficient = 0.361**), usefulness (Pearson correlation coefficient = 0.404**), future behavioral intention to use (Pearson correlation coefficient = 0.405**), and the capability students had before they used the QRCIG were also crucial parameters. These results supported Davis' statement (1989) that, when users' recognition of perceived ease of use of information is high, they tend to hold positive attitudes towards the information system. When the attitude is positive, users tend to hold positive attitudes towards the usefulness of the information.

A TAM pattern derived from information accessibility, ease of use, usefulness, attitudes, and behavioral intention to use perceived by students regarding the QRCIG by using path analysis, as shown in Figure 3. According to Figure 3, the Pearson correlation coefficients indicating students' perceived ease of use and usefulness, attitudes, and behavioral intention to use regarding the QRCIG ranged from 0.341 to 0.852, indicating that these parameters are highly relevant at a medium to high level. This result is consistent with that of Mayer & Moreno (2002), who studied multimedia aids.

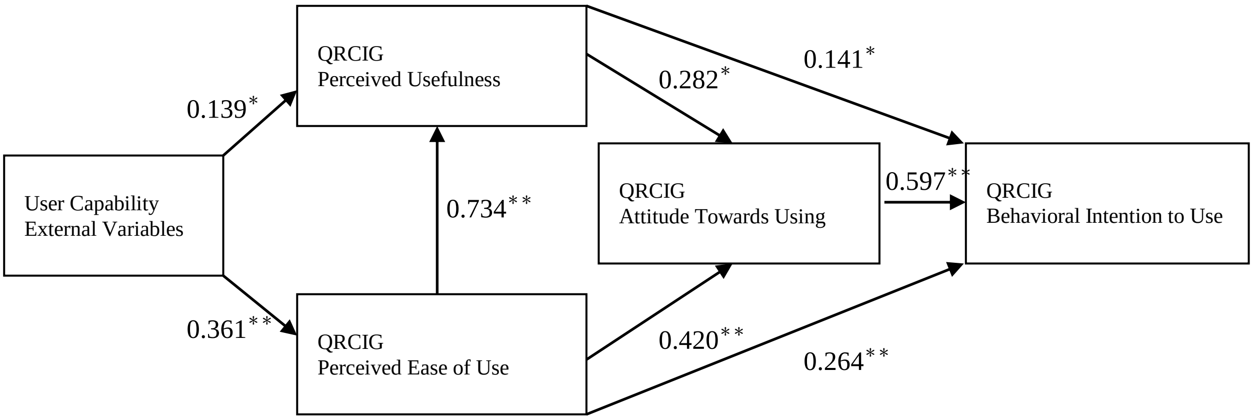

Figure 3. Technology Acceptance Model for the QRCIG

In the TAM, each route carries high significance. The correlation coefficient between perceived ease of use and usefulness of the QRCIG was as high as 0.734**, indicating that if students' perception of ease of use towards the information system is high, then their perception of its usefulness is positive.

Moreover, the correlation coefficient between the attitude towards using and the behavioral intention to use of the QRCIG system was 0.597＊＊, indicating that the higher the attitude towards using of the QRCIG was, the more positive people's perception of the system was. Furthermore, by using path analysis, correlation coefficients are significant in both of perceived usefulness and perceived ease of use of the QRCIG with the attitude towards using, which means that the higher the perceived usefulness of QRCIG and perceived ease of use were, the more willing students' attitude towards using QRCIG was. Several scholars who used the TAM demonstrated that "behavioral intention to use" can be used as a predictive force (Mathieson, 1991; Szajna, 1996). Our results illustrate that the tools used in the present study triggered high perceived ease of use and perceived usefulness among subjects, causing them to hold positive attitudes about their intention to use the system.

5. Conclusion

We designed a learning system integrating information technology and outdoor education; this system inspires novel ideas about curriculum design, pedagogy, and the learning of students. Moreover, the system links teachers and students and encourages students to use various methods to achieve educational goals and to have positive interactions with the environment. The analyses demonstrated that the tools developed in the present study satisfy the principles of recognition and integration. The TAM analysis shows that users' behavioral inclination determines their inclination towards specific information technologies, which indicates that users who participated in the present system attained positive learning outcomes and positively evaluated the system.

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