Research and Trends in the Field of Technology-Enhanced Learning from 2006 to 2011: A Content Analysis of Quick Response Code (QR-code) and Its Application in Selected Studies

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ABSTRACT

This study provides a content analysis of selected articles in the field of QR code and its application in educational context that were published in journals and proceedings of international conferences and workshops from 2006 to 2011. These articles were cross analysed by published years, journal, and research topics. Further analysis was carried out according to research settings, participants, research design types, research methods and findings. It was found from analysis that QR code technology cover a wide range of applications such as augmented reality game, science education, student assignment submission, library catalogue system, communication tools in large classroom environment, system for learning language, collaborative mapping and knowledge management environment, multimedia access tools, assessment tools and so forth. Although the technology covers a wide range of applications, the reported effectiveness of QR technology was not conclusive as most of the data were self-reported such as from questionnaire survey. Most of the studies involved short term research which would not be sufficient to address the complexity of technology integration in educational settings. Hence, it is suggested that future studies should consider offering more reliable and richer findings through longitudinal study and providing inter-observer and intra-observer agreement reliability.

Keywords: *QR-codes, Quick response code, 2-D barcode, Education*

INTRODUCTION

QR Code (abbreviated from Quick Response Code) is a multifaceted two dimensional graphical description of data. Its capability has gone beyond the traditional linear barcode (which is mainly used to automate supermarket checkout systems and as automatic identification and data capturing tag) due to its large storage capacity and fast readability. A long piece of multilingual scaffolding text, URL of a linguistic mastering website, a direct link to Moodle or Schoology, an automated SMS message to a formative assessment application, a direct access to students' science electronic portfolio, or even an augmented reality object can be amalgamated into the small 2D matrix barcode. Affiliated with a sufficiently equipped mobile phone or any handheld devices, QR code is able to power a speedy and ready connection between learners, instructors and digital content available.

Although QR code has existed for almost two decades, there was still a lack of research on of its usage in educational setting. However, the interest to integrate this technology in education is rising due to the rapid advancement in mobile and wireless technology, and low technical barrier to encode and decode. These provisions enable educators to explore its potential creatively. In this paper, the authors explored the usage of QR code in educational context. The investigative journey was guided by the following questions:

1. How was QR code being used in educational settings?
2. What types of research methods have been applied using QR codes?
3. What data collection methods were employed in the research?
4. What research topics have been investigated on QR code in education settings? And what were their findings?

BACKGROUND

QR CODES

QR Code was invented by Denso Wave Incorporation (a Toyota subsidiary) in 1994. It is one of the most popular types of two-dimensional barcodes (Furht, 2011). which was designed to allow its contents to be decoded at high speed (Denso-Wave, 2011). The code consists of black modules (or coloured) arranged in a square pattern on a white background (or coloured). The information encoded can be text, URL, SMS, email, vCard, video, spread sheet, among many others. Initially QR code was confined to industrial uses; it has gained more attention in the commercial world and even in education lately due to the dissemination of smartphones. The recent diffusion of this technology over a broad range of applications is attributed to its features as follows.

(a) The patent right owned by Denso Wave is not exercised;

(b) QR Code specification is disclosed to the public by the company;

(c) QR Code is capable of handling several hundred times more information than conventional linear barcode;

(d) QR Code can be read even if distorted;

(e) QR Code has high (up to 30%) correction capability against dirt and damage;

(f) QR Code enables a linking functionality which is possible for a QR code to be represented by up to 16 QR codes at maximum;

(g) Information can be easily encrypted in a QR code to provide confidentiality;

(h) QR Code can handle various languages.

QR CODES IN EDUCATION

The study of QR code in education can be considered as a subset of mobile learning (m-learning). Resent research in m-learning seems to indicate that digital contents, concurrently associated with authentic learning environment, tends to enhance learners' interest (Liu, Li, & Carlsson, 2010), motivation (Liaw, Hatala, & Huang, 2010), and achievement Hwang, Kuo, Yin, & Chuang, 2010). Despite its potential, m-learning is self-confined by usability factors of the mobile handheld devices in use such as limited screen size, text input and editing functionality. Limited screen size has been a stimulating condition for learners to perform even the most basic internet navigation tasks (Jones, Buchanan, & Thimbleby, 2003), and educational related tasks (Luchini, Quintana, & Soloway, 2004). Inter alia, the situation is aggravated by limited input and editing functionalities of these devices (Metcalf & Rogers, 2010). Clayton (2010) stated in the abstract, the limited input functionalities of mobile devices means accessing stored information, digital content and support services is often an unfriendly user experience ultimately affecting the uptake of mobile-technologies in educational institutions. In view of these reasons, OR code is considered as promising technology to offer speedy and ready access to multimedia learning resources, information, and services (Elena, 2009). The use of QR codes in education still in its infancy, some typical examples, among many others, is provided as follow.

(a) Review of embedded information directly (Shaof, Pollak, & Schneider, 2004);

(b) Access website resources from QR codes printed on posters, flyers, and handbook (Chaisatien, & Akahori, 2007);

(c) A QR code associated with library catalogue (Bath, 2010);

(d) Assignment submission sheets with printed QR code (Bath, 2010);

(e) Spontaneously generated of a QR code to the bottom of Moodle print-outs (Bath, 2010).

SIGNIFICANCE OF THIS REVIEW

This paper is expected to be able to facilitate researchers and practitioners in identifying the current research topics, research methodologies, data collection methods and usage of QR code in education settings. Moreover, it suggests potential directions for future research as well as some guidelines of the nature of future research.

METHOD

SOURCES OF DATA

The searches for empirically based articles were carried out in two stages. In the first stage, the authors examined articles found in electronic databases using keywords including QR code, 2D barcode, and education. The electronic databases used were Academic Search Premier, ERIC, ProQuest, Web of Science, PsycARTICLES and Google Scholar. In the subsequent stage, further searches on journal articles, as well as articles presented in conferences which were cited in the articles found in the first stage were conducted.

As of 10 April 2012, the serach yielded a total of 36 articles. Out of 36 articles found, 17 were identified for the current review. The rest of the articles were excluded because they were found to be non-empirical (opinion papers, conceptual articles, literature review) or unrelated to the subject of the use of QR code in education. Nonetheless, they were used as 'background' references whenever appropriate.

DATA ANALYSIS

The basic unit of analysis for the current review was the individual empirical articles identified from the sources of data. Creswell's guideline was adopted where summary of major research topics, weaknesses in current research, direction for future study related to the subject were expected to be drawn from the current review (Creswell, 1994).

To answer the first research question, "How was QR code being used in educational settings?", Wing Sum, Cheung, and Hew (2009) outline was used to initiate the analysis and coding. Initially, the guideline consisted of 5 categories namely multimedia access (MA), Connectivity (Con), capture (Cap), representation (Rep), analytical (Ana), two more categories were added by Cheung and Hew (2009), which were assessment and task management.

To address the subsequent research questions, "What types of research methods, have been applied by using QR code?"; "What data collection methods were used in the research?", "What research topics have been conducted and what were their major findings?", the guidelines by Shih, Feng, and Tsai (2008) and Cheung and Hew (2009) were used to guide the analysis and coding. For types of research methods, three major types were put forward: descriptive research, experimental research, and developmental research; in terms of data collection, five types of data collection methods were laid down: test or quiz, questionnaire or survey, interview, observation, and content analysis; with regard to research topics, seven topics were addressed: usage profile, viability as an assessment tool, learning outcomes, motivation, instructional approach, cognitive psychology characteristics, and learning environment.

RESULTS AND FINDINGS

USES OF QR CODE IN EDUCATIONAL SETTINGS

Multimedia access tools

This refer to the use of QR code as a ready and speedy link to multimedia resources including text, audio file, video clips, web page, databases (Churchill & Churchill, 2008). For instance, users of Pediaphon in Bischoff (2007) were distributed 2D barcodes embedded with URL to a specific audio file generated from the well-known Wikipedia.

Connectivity tools

This account for the use of QR code as a convenient way to connect and exchange ideas, ask questions, get in touch with potential clients, engage in discussions (Shih, Feng, & Tsai (2008). In this study, 3G mobile phone was used to scan a QR code and users were redirected to a URL which fetched an asynchronous communication page on the web.

Capture tools

Capture capability enables users to take photos, videos, and audio clips (Churchill & Churchill, 2008). By using QR code, the captured media can be shared directly with the intended audience conveniently. In players of SciMyst were required to capture the tag attached to a specific object found as an evidence of solving an enigma (Sedano, Laine, Vinni, & Sutinen, 2007).

Representational tools

This affordance refers to the ability to create representations of knowledge and ideas such as concept map by using mobile handheld devices. The current review revealed that there was a lack of study in this area. However, typical example was given in Dieterle and Dede (2006).

Analytical tools

This applies to the use of some application in a mobile handheld device to manipulate data or variables (Churchill & Churchill, 2008). The current review found no study in this area. Nevertheless, an example could be found in Hennessy (1999).

Assessment Tools

This can be taken as the usage of handhelds to answer examination questions, tests, quizzes and assessment questions (Cheung & Hew, 2009). By using QR code, users can be resolved to the web page that contains the targeted test items directly. In Susono and Shimomura (2006), QR code was used to answer classroom assessment questions.

Task management tools

This connects with the employment of QR code to trigger the personal information managers which store and organise a user's address book, contact information, calendar, task list and so forth. In the current paper, none of the articles identified geared into this direction. A typical example for this usage can be found in Yamamoto and Akahori (2006).

Analysis revealed that the two most frequent uses of QR code in educational settings were as multimedia access tools (57.7%) and as communication tools (17.9%) and three areas were not explored in the setting of this review (QR code as enabler of representation tools, analytical tools, and task management tools) (See Tab. 1 and Fig. 1).

Table 1. Uses of QR code

Uses of QR code	Percentage of Usage	Count
Multimedia access	57.7%	15
Connectivity	15.4%	4
Capture	11.5%	3
Representation	0.0%	0
Analytical	0.0%	0
Assessment	15.4%	4
Task Management	0.0%	0

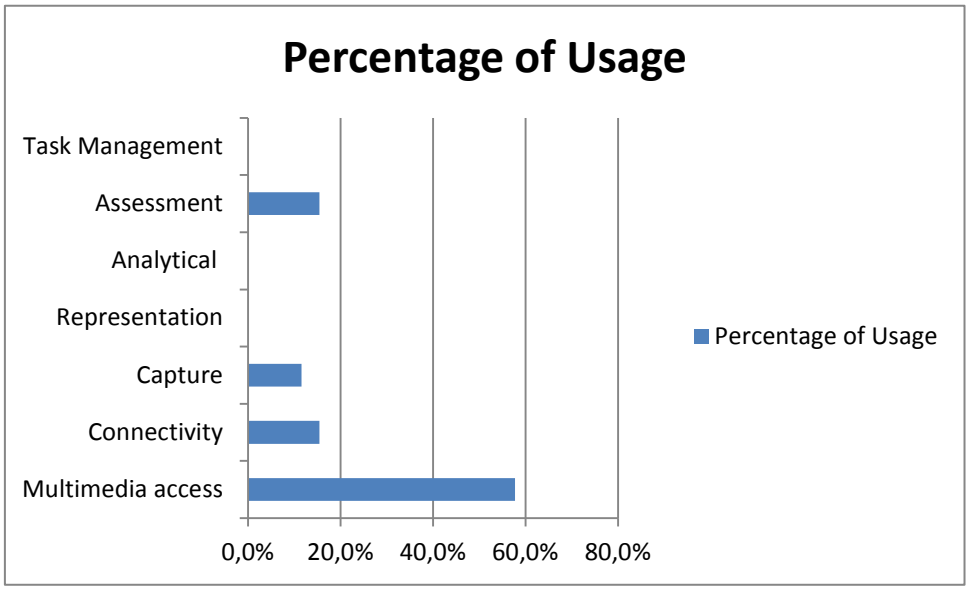

Figure 1. Uses of QR code

TYPES OF RESEARCH METHODS

In addressing the second research question, three methods were put forward, experimental, descriptive and developmental research.

Experimental Research

This type of research involved treatment group, control group, testing hypotheses or theory and the employment of random sampling (Ozcelik & Acarturk, 2011). We identified three experimental studies in the current review.

Descriptive Research

Descriptive research describe state of affairs using surveys, ethnography, and so forth (Fraenkel & Wallen, 2006). This type of research is typically naturalistic and depicts conditions as they exist in a particular setting (Ross & Morrison, 1997). The authors found a total of 10 studies dealing with this method.

Developmental research

This type of research usually looked into the analysis, design, development, implementation and evaluation process of an educational intervention based on certain theoretical framework (Richey & Nelson, 1996). The development of technology-enhanced learning system is one of the examples of this research method. Developmental research usually involves an iterative cyclical processes of design, enactment, analysis, evaluation and redesign (Collins, 1992). In the current review, five developmental research studies were found. However, almost all studies reviewed in this paper incorporated certain elements of developmental research but only the studies which reported the complete process as mentioned above were tagged as developmental research. For instance, in Susono and Shimomura (2006), the authors reported on a project using mobile phones and QR code for formative class assessment, however it was categorized as descriptive research instead of developmental research as the report focused on describing students' perceptions and experience rather than the developmental process. One typical example of this research can be seen in Chen and Choi (2010). The researchers designed and developed a history learning module which was integrated with a location aware online platform called Visible Past.

Tab. 2 and Fig. 2 displayed the summary of research methods used in QR code related researches. The finding indicated that descriptive research was the dominant type of research method (52.9%), followed by developmental research (29.4%) and experimental research (17.6%). The finding was consistent with the prediction by Kunpfer and McLellan (1996) about the increasing number of descriptive research studies in educational settings. This was probably because the adaptation of QR code in education was still in its infancy and thus researchers were still in the stage to understand more about the phenomenon.

Table 2. Research Methods

Research Method	Percentage of Research Method (%)	Count
Experimental research	17.6%	3
Descriptive research	52.9%	9
Developmental research	29.4%	5
Total	100.0%	17

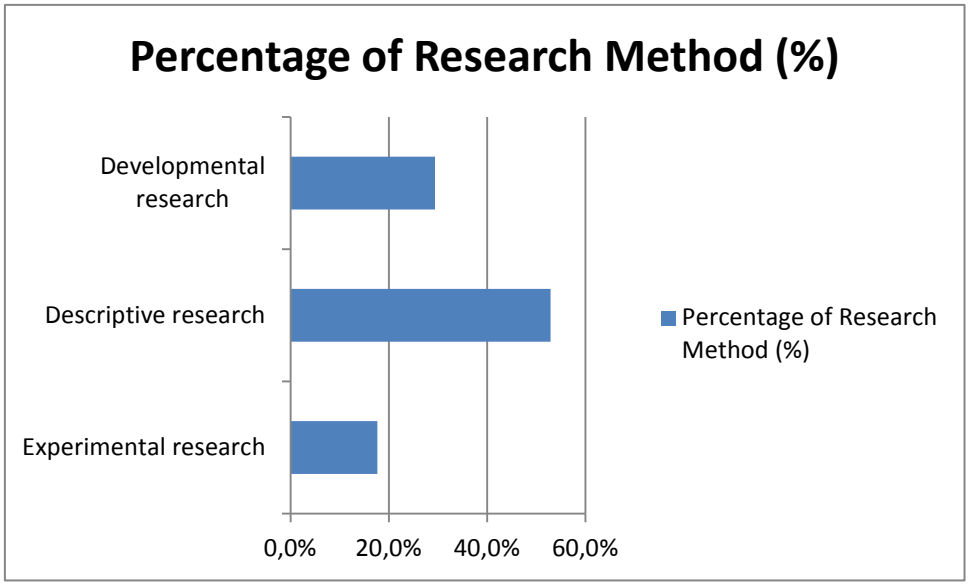

Figure 2. Research Methods

DATA COLLECTION METHODS

The categories of data collection used in the current review of past empirical studies including test or quiz, questionnaire or survey, interview, observation and content analysis.

Test of Quiz

Typical examples of this collection method are the administration of pre-test and post-test for experimental research. Pre-test is an instrument to test participants' prior knowledge before the intervention. In other words, participants in both treatment and control group must be compared on a fair ground. Post-test is usually used to evaluate participant's performance after the removal of the intervention. In Ozcelik and Acarturk (2011) pre and post-tests were administered to students to evaluate their performance under two approaches of multimedia learning.

Questionnaire or Survey

Judd, Smith and Kidder (1991) defined survey as "…simply be interested in documenting the distribution of some variables of interest in some population." Likert-scaled items used to collect data about the distribution of students' perceived usefulness pertaining an intervention could be a good example. In Tsung, Tan, and Chu (2007) questionnaire survey approach was used to evaluate the distribution of perceived easiness, usefulness and attitude of students towards a learning system called HELLO.

Interview

Interview means conversation with information (Pratt, 1980). Interview is conducted mainly to collect data which is not possible to obtain without face-to-face interaction between researcher and the subjects of the research (Guba & Lincoln, 1981). In the current review, two studies were found using this method. Ching-yin Law and Simon (2010) used a questionnaire to collect data pertaining to perceived usefulness and interest of participants in Math Trail.

Observation

Observation is normally used to collect 'non-verbal' data in order to understand more about the state of affairs and provide critical thought about the behavior of the informant Mohamad Nor bin Mohamad Taib. (2001). Observation is done in order for a researcher to hear, see, observe and feel in particular situation in order to gather data. From the literature, four realistic studies were using this method in data collection. In Ching-yin Law and Simon (2010), this method was used to understand participants' behavior in the course of the planned activity.

Content Analysis

This method is employed by researchers to investigate the behavior of participants by gathered written contents through comparison and categorization (Fraenkel & Wallen, 2006). We found a total of seven studies dealing with this method of data collection. For example, in Bischoff (2007), time log was used to understand online users' behavior in respect to the usage of Pediaphone.

Result (see Fig. 3 and Tab. 3) showed that questionnaire or survey (37.9%) and content analysis (24.1) were the two most common data collection methods. The least common method was interview (6.9%).

Table 3. Data Collection Methods

Data Collection Method	Percentage of Research Topic (%)	Count
Test / quiz	38.5%	15
Questionnaire / Survey	28.2%	11
Interview	5.1%	2
Observation	10.3%	4
Content Analysis	17.9%	7
Total	100.0%	39

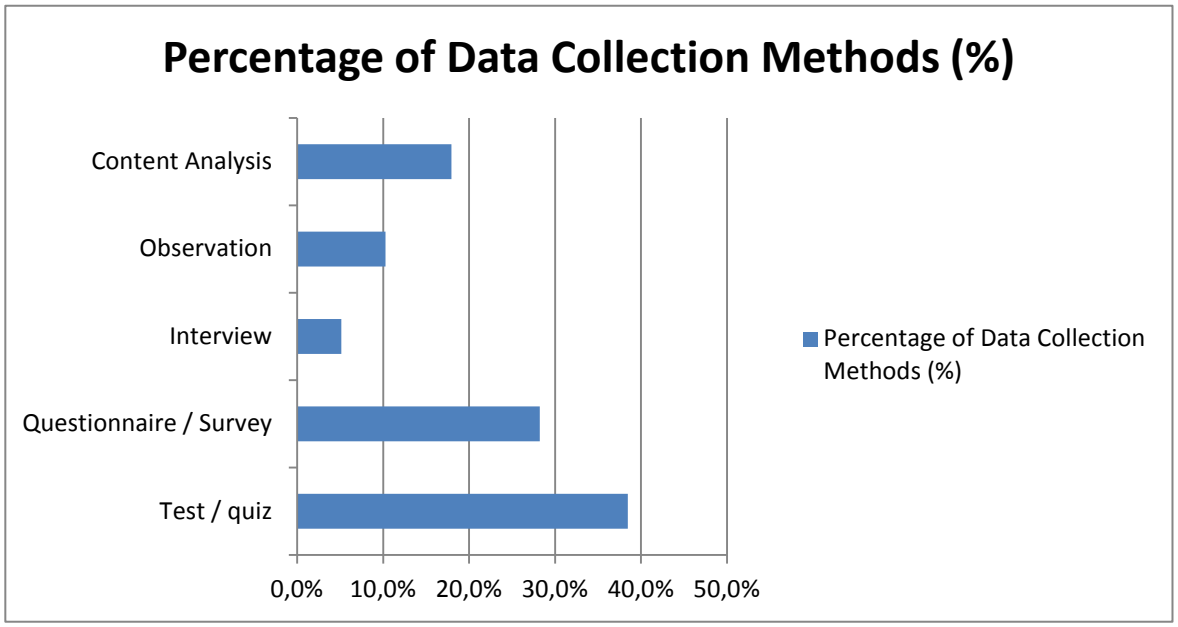

Figure 3. Data Collection Methods

RESEARCH TOPICS

Six research topics were used to categorize the topics research area covered in the previous studies: utility profile, viability as an assessment tool, learning outcomes, motivation, instructional approaches and cognitive psychology characteristics.

Usage Profile

This topic investigate issues such as types of mobile devices owned, subscribed service provider, installation of QR code reader, and mobile phone with an integrated camera. Eight studies were found dealt with this topic. For instance, percentage of participants that access internet via mobile phone was investigated in Hend S. Al-Khalifa (2008).

Viability as an Assessment Tool

This refers to the research which examined the usability of mobile handheld devices with associated QR code application for various types of assessment. In the current review, Susono and Shimomura (2006), Ching-yin Law and Simon (2010), Sedano, Laine, Vinni, and Sutinen (2007) and Hend S. Al-Khalifa (2008) dealt with this topic. The types of assessment varied from MCQ auto-corrected question to semi-paper-based self-evaluated assessment.

Learning Outcomes

This research topic examined the interaction between the use of QR code and students' learning performance. We found four studies dealt with this topic. In Ozcelik and Acarturk (2011), learning outcomes (retention, transferable skill and matching) were evaluated in relation to two different learning approaches.

Motivation

This research topic dealt with students' or teachers' beliefs, attitudes, interest and so forth. We found two studies under this topic. In Sedano et al. (2007), interest and motivation of SciMyst participants were investigated by using a questionnaire.

Instructional Approaches

This type of research refers to various types of learning approaches such as multimedia learning, cooperative learning, game-based learning, and etc. A total of 11 studies related to this topic were found. For example, outdoor learning and contextual learning approaches were investigated in Tsung, Tan, and Chu (2007).

Cognitive Psychology Characteristics

This topic looks into cognitive related variables such as cognitive load, cognitive style, knowledge representation of learners (Shih, Feng, & Tsai, 2008). In the current review, two studies were found related to this topic. For instance, in Ozcelik and Acarturk (2011), students' cognitive load in different instructional approaches was examined.

Finding showed that instructional approaches and usage profile were the two most common research topics. Lack of research was found in motivation and cognitive psychology characteristics (see Fig. 4 and Tab. 4).

Table 4. Research Topics

Research Topics	Percentage of Research Topic (%)	Count
Utility Profile	25.8%	8
Viability as an assessment tool	12.9%	4
Learning outcomes	12.9%	4
Motivation	6.5%	2
Instructional approaches	35.5%	11
Cognitive Psychology characteristics	6.5%	2
Total	100.0%	31

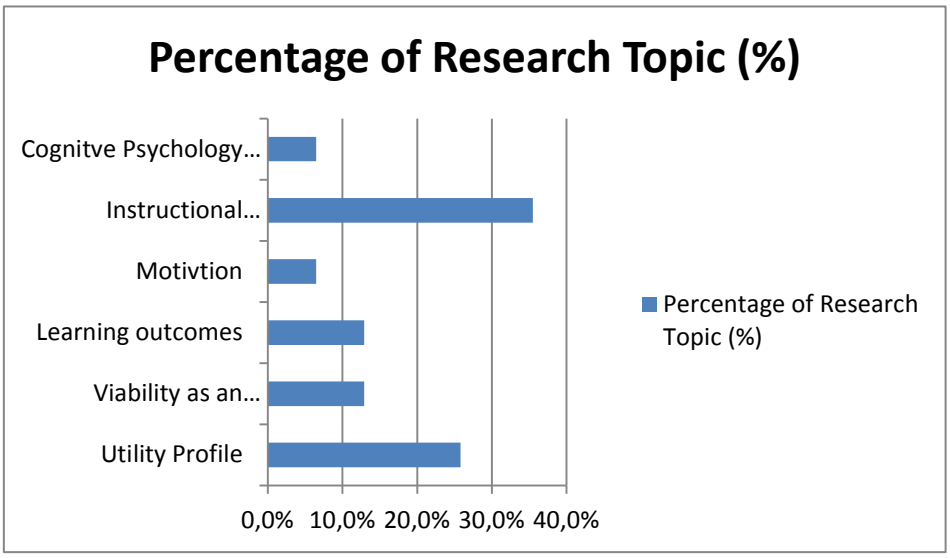

Figure 4. Research Topics

DISCUSSION AND CONCLUSION

MAJOR RESULTS

In this section, the authors summarise and discuss the major findings, and limitations of previous empirical studies. Later on, some recommendations for future studies related to the use of QR code in education are provided. The major results are:

1. QR code was mainly used as a speedy and ready access to multimedia contents such as web site, databases, audio and video files, question and answer texts and so forth. The frequent use of QR codes in this aspect is expected as the code was initially developed to provide quick access to embedded information. Even though the uses of mobile handheld devices are widely accepted in education now, its weaknesses such as limited display area and ineffective input method have restricted its development. The association of QR code and handhelds offers a potential solution due to its capability to embed information such as URL to a targeted website which otherwise could be very redundant for a potential user to key in the lengthy URL.

2. Descriptive research was the most common type of research method used within the setting of this review. Most probably this is due to the association of QR code with handheld device in education is still in its infancy; many of the researches were still in the stage to explore the usability and feasibility in order for researchers to understand more about the happening, dynamism and complexity of this technology. This is evidenced by almost all descriptive research reviewed were majority part of a developmental project carried out by the researchers to investigate the affordability of this technology.

3. The most frequent data collection method was questionnaire or survey. Most probably, this is because questionnaire or survey method enables the researchers to collect data from a relatively large pool of participants easily and quickly. Moreover, the data collected also were easier to process.

4. Most of the research topics covered in the previous studies involved the adequacy of QR code as an enabler in various types of instructional approaches. Instructional approaches covered included experiential learning, collaborative learning, discovery learning, science-technology-society approach and so forth.

LIMITATIONS OF PREVIOUS EMPIRICAL STUDIES

Our review found several limitations concerning previous empirical research on the use of QR code in education. First, most of the previous research (44.8 %) based their findings on respondents' self-report data such as questionnaires and interviews. By using questionnaires, respondents may answer superficially especially in a prolonged survey. The mistakes of asking too many questions and irrelevant questions should be minimized. Moreover, it is not possible for a participant to elaborate on points in the questionnaire as questionnaire is usually structuralised with limited options. In addition, questionnaire survey takes place after an event, and participants may ignore critical issues.

Second, most of the research were limited in their duration, varying from a few hours to a semester. Short term research is not sufficient to investigate the dynamism and complexity of technology integration in the educational setting. One of the limitations of short term studies is bias of the result due to novel effect.

Third, research topics covered in the previous empirical studies were limited. Research in certain important areas in teaching and learning such as cognitive psychology characteristics, learning environment, motivation and information processing were still in deficiency.

RECOMMENDATIONS FOR FUTURE STUDIES

In the light of all above, the authors suggest that future studies should provide richer and more reliable data so that results and findings can be fittingly interpreted by the readers. Second, future study should pay more attention to longitudinal research in order to understand more about the long term effects of QR code integration in education. Third, research topics such as mental model, cognitive style, interactive learning environment, learning community, behavioural change should be attempted.

Appendix A. Summary of reviewed studies

Title	The Pediaphon- Speech Interface to the free Wikipedia Encyclopaedia for Mobile Phones, PDA's and MP#-Players	Mobile SRS: A Classroom Communication and Assessment Service
Source	Database and Experimental Systems Application, 2007. DEXA 2007. International Workshop. Pp. 575-579	Innovations in Information Technology, 2008 IIT 2008. International Conference. Pp. 342-346.
Author(s)/ Year	Andreas Bischoff/ 2007	Hend S. Al-Khalifa/ 2008
Samples	On-line users	150 undergraduate students
Research Objectives	1. to evaluate the possibility of QR code to be used as immediate access to a web-based learning resource.	1. to design and evaluate a mobile learning system with QR code to enhance communication and assessment in large scale classroom.
Method	descriptive	descriptive
Finding	1. less than 5 % of request utilize the mobile phone with QR code interface to gain access to the web-based learning resource.	1. the implemented system seems to be potential in enhancing communication and assessment in large scale classroom.

A Pilot Study on 3G Mobile Phone and Two Dimension Barcode in Classroom Communication and Support System	Advance Learning Technologies, 2007. ICALT 2007, Seventh IEEE International Conference. Pp. 111-113	Prach Chaisatien and Kanji Akahori/ 2007	50 undergraduate and graduate students	1. To conduct a pilot study using a mobile learning system with QR code to enhance communication and information access in a big class.	descriptive	1. The system is useful in collecting large amount of information in short time in a classroom.

Where is The Answer?- The Importance of Curiosity in Pervasive Mobile Games.	Reducing The Spatial Distance between Printed and Online Information sources by means of Mobile Technology Enhances Learning: Using 2D Barcodes	Designing Online Collaborative Location-Aware Platform for History Learning
Future Play' 07. Proceedings of the 2007 conference on Future Play. Pp. 46- 53.	Computers & Education. 57 (2011) 2077-2085.	Journal of Educational Technology development and Exchange. 31(1), 23-26
Carolina Islas Sedano, Teemu H. Laine, Mikko Vinni and erkki Sutinen/ 2007	Erol Ozcelik and Cengiz Acarturk/ 2011	Xiaojun Chen and Jea H. Choi/ 2010
45 players of SciMyth during Sci Fest 2007, Finland	44 undergraduate students	High school history students
1. To study the possibility of mobile handheld and QR code as a mean of educational play tool. 2. to identify the elements in a pervasive game environment which can trigger the interest of participants.	1. To investigate whether the reduced spatial distance between printed materials and online information sources enhance learning outcomes.	1. To study the possibility of printed QR code on textbook and hand-out as a mean to access web-based learning resources.
descriptive	Experimental	developmental
1. Mobile phone as a play tool or controller in pervasive gaming was significantly potential. 2. Curiosity and challenge seems to be the main driving force for finishing the game. 3. The use of the common environment as a playground seems to be a path of for the social interaction of different types of players playing at the same time	1. Participants in the Experimental group (paper-plus-mobile phone) had higher retention test scores than the participants in the control group (paper-plus-computer). 2. Mobile handheld devices have further advantages over notebook computer in	1. QR code can be used as a speedy and ready access to web-based learning resources.

2D Barcode and Augmented Reality Supported English Learning System	QR Codes in Education
Computer and Information Science, 2007. ICIS 2007. 6th IEEE ACIS International Conference. Pp. 5- 10	Journal of Educational Technology development and Exchange. 3(1), 85-100
Tsung-Yu Liu, Tan-Hsu Tan and Yu-Ling Chu/ 2007	Ching-yin Law and Simon So/ 2010
College students	K2 students
1. To construct a 2D barcode handheld augmented reality supported learning system for English learning. 2. To investigate the effectiveness of the learning system. 3. To investigate the attitude of students in using the implemented learning system.	1. To study the possibility of mobile handheld development with QR code as a learning tool in Maths Trail (an outdoor Maths learning activity). 2. To study the possibility of mobile handheld development with QR code as a mean to promote self-directed multimedia learning activities. 3. to study the possibility of mobile handheld development with
descriptive	descriptive
1. The learning system seems to be capable of improving listening, speaking, reading and writing ability. 2. The learning system seems to be capable of increasing motivation to learn. 3. Mobile handheld development with QR code is highly potentials in education.	1. Mobile handheld development with QR code is highly potential in education.

Using Mobile Phones and QR Codes for Formative Class Assessment	探討結合QR-code與無線網路建置國小校園生態教學互動式數位學習系統之研究	Realizing the Ubiquitous STS Collaborative Learning Environment: Using Handheld development with 2D-Barcode and E-Learning Platform
FORMATEX 2006. Current development in Technology-Assisted Education (2006). Volume 2: Technological Science Education, Collaborative Learning, Knowledge Management. Pp. 1006-1010	Dissertation.(http://140.127.82.166/handle/987654321/2286)	Sensor Networks, Ubiquitous and Trustworthy Computing, 2006. IEEE International Conference. Pp. 130-137
Hitoshi Susono and Tsutomo Shimomura/ 2006	`	Ruey-Ming Chao, Ta-Sheng Lan, Jia-Nan Chang and Joy Iong-Zong Cheng/ 2006
College students	42 primary students	Primary grade 5 students
1. To study the possibility of using mobile handheld development with QR code for formative class assessment.	1. To construct a ubiquitous learning environment by using mobile handheld development with 2D barcode in natural science learning.	1. To construct a ubiquitous collaborative learning environment by using mobile handheld development with 2D barcode.
descriptive	Experimental	descriptive
1. Using mobile handheld development with QR code seems to be more useful in a large-scale class (80 - 100 students) .	1. Mobile handheld development with QR code significantly enhance learning outcomes.	1. mobile handheld development with QR code seems to be useful in promoting ubiquitous collaborative learning.

Outdoor Education Support System with Location Awareness Using RFID and Symbology Tags	Scan & Learn! Use of Quick Response Codes and Smartphones in a Biology Field Study	The Implementation of U-Learning Management System with QR Code Integration and Its Application on Nature Science
Journal of Educational Multimedia and Hypermedia, 16(4) Pp. 411-428	The American Biology Teacher, Vol. 73, No. 8, pages 485–492	Dissertation. (http://ndltd.ncl.edu.tw/cgi-bin/gs32/gsweb.cgi?o=dnclcdr&s=id=%22098TMTC5480034%22.&searchmode=basic)
Noritaka Osawa/ 2007	Jun-Ki Lee, Il-Sun Lee, Yong-Ju Kwon/ 2011	Chih-Hung Chen/
24 undergraduate students	Not mentioned	104 grade six primary students
1. To investigate whether the 2D symbology tag system is a more preferable mode of outdoor education support system with location awareness as compared to RFID tag system.	1. To develop a teaching method and process that incorporates quick response (QR) codes and smartphones into field trips for biology classes.	1. To development a suitable U-Learning Management System with QR Code Integration and to evaluate the system. 2. To investigate the influence of U-Learning on students' science process skills and learning achievements. 3. To investigate the pupils' attitude toward the system and ubiquitous learning.
Experimental	descriptive	descriptive
1. Both RFID and 2D symbology tags were regarded highly useful for outdoor learning by students. 2. 2D symbology tag system using a small and lightweight mobile phone was preferred.	1. Learning via QR-code-decoding on smartphones may more effectively motivate interest in learning about natural fauna than traditional field studies that use printed field guide.	1. The ubiquitous learning system is capable of improving students' science process skills significantly. 2. Students consider that using QR Code for the ubiquitous learning is very interesting and could learn more authentically, could observe more effectively, and could learn more.

Learning Historical and Cultural Contents via Mobile Tresur Hunting in Five-harbor District of Tainan, Taiwan	Utilizing The Quick Response (QR) Code within a Japanese EFL Environment	Augmenting Paper-Based Reading Activity with Direct Access to Digital Materials and Scaffolding Questioning
The 6th IEEE International Conference on Wireless, Mobile, and Ubiquitous Technologies in Education	The Jalt Call Journal. 5(2) 15-28.	Computers & Education. 57 (2011) 1705- 1717.
Stis Wu, Alex Chang, Maiga Chang, Yu-Ren Yen, Jia-Sheng Heh/ 2010	Damian J. Rivers/ 2009	Nian-Shing Chen, Daniel Chia-En Teng, Cheng-Han Lee and Kinshuk/ 2011
Primary students	132 undergraduate students	77 undergraduate students
1. to design and evaluate a mobile with QR code driven treasure hunting learning model for history and culture learning.	1. To investigate the possibility of mobile handheld development with QR code driven activities into a Japanese university English as a Foreign Language (EFL) classroom.	1. To evaluate the relative effectiveness of direct access to the digital materials using QR code and the reading strategy of scaffolding questioning in improving students' reading comprehension.
descriptive	descriptive	Experimental
1. Treasure hunting learning model seems to work well for learning historical and cultural contents in field trip.	1. QR codes do have the potential to be adopted as a part of an EFL learning curriculum although for the students to accept them as a valid learning facilitator, their level of knowledge concerning the role of the mobile phone within educational environments must first be developed.	1. Scaffolding questioning was found to be more effective in improving students' reading comprehension. 2. When more than one digital materials are available for a particular content, QR code is advised to be used as a portal to the resource repository rather than placing multiple QR codes for the content. 3. Efficiency of QR code reader could be a potential hampering factor pertaining the ease of use of the technology

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