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Colloquium

Research trends in mobile and ubiquitous learning: a review of publications in selected journals from 2001 to 2010

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Introduction

Owing to the rapid advance and popularity of wireless communication and mobile technologies, mobile and ubiquitous learning has become more and more important (Chu, Hwang, Tsai & Tseng, 2010). Numerous studies about the use of mobile and wireless communication technologies in education have been reported, in which these technology-enhanced learning approaches are referred to as mobile or ubiquitous learning by the researchers (Chu, Hwang & Tseng, 2010; Shih, Chuang & Hwang, 2010). There have been several definitions for mobile and ubiquitous learning. A widely accepted definition of mobile learning is 'using mobile technologies to facilitate learning', while a popular definition of ubiquitous learning is 'learning anywhere and at anytime' (Hwang, Tsai & Yang, 2008; Shih, Chu, Hwang, & Kinshuk, 2010). Although these definitions have been given from different aspects, they share the same idea, that is, the mobile devices (eg personal digital assistants, cellular phones or portable computers) play an important role in the learning activities no matter whether the activities are conducted in the field or in the classroom (Chen, Hwang, Yang, Chen & Huang, 2009; Hwang, Yang, Tsai & Yang, 2009; Vavoula, Sharples, Rudman, Meek & Lonsdale, 2009).

In the past decade, various studies concerning mobile and ubiquitous learning have been conducted in museums, classrooms or labs (Hall & Bannon, 2006). For example, Reynolds, Walker and Speight (2010) arranged students to explore the museum environment and collections with mobile devices. Chiou, Tseng, Hwang and Heller (2010) also developed an adaptive navigation support system for guiding students to learn in museums with mobile devices. Furthermore, Hwang and Chang (2011) reported a learning activity of a local culture course, in which students were guided to learn in a temple using mobile devices.

In addition to these indoor activities, an increasing number of mobile or ubiquitous learning activities have been conducted in the field (Chu, Hwang, Huang & Wu, 2008; Tan, Liu & Chang, 2007). For example, Chu, Hwang and Tsai (2010) conducted a ubiquitous learning activity for a natural science course, in which individual students were equipped with a mobile device that guided them to observe the features of plants in the school campus. In another study, Hung, Lin and Hwang (2010) conducted a series of mobile learning activities for ecology observations and data collection in a wetland in southern Taiwan.

With the worldwide spread of journals in educational research, such technology-enhanced research has received much attention since the turn of the century. Researchers have predicted that more technology-based learning will occur with the newly developed devices or concepts, and mobile and wireless communication technologies could play an important role in such a revolution of education (Liu & Hwang, 2010). Understanding the status of such emerging

research would be helpful to researchers in related fields to choose appropriate topics for further exploration (Hoffler & Leutner, 2007; Seo & Bryant, 2009). Moreover, a survey of such emerging learning research could provide policymakers with a good reference for making critical decisions (Alper & Gulbahar, 2009; Karatas, 2008; Shih, Feng & Tsai, 2008; Zawacki-Richter, Bäcker & Vogt, 2009). In this study, we intend to investigate the research status of mobile and ubiquitous learning from 2001 to 2010. Six major research journals related to technology-enhanced learning were selected for analysis, including the *British Journal of Educational Technology* (BJET), *Computers and Education* (C&E), *Educational Technology & Society* (ETS), *Educational Technology Research & Development* (ETR&D), *Journal of Computer Assisted Learning* (JCAL) and *Innovations in Education and Teaching International* (IETI). These journals have been widely accessed and are recognised to having high impact factors as released by the Institute for Scientific Information (ISI) Journal Citation Reports. We aim to answer three research questions as follows:

1. What is the status of the mobile and ubiquitous learning articles published in these selected journals from 2001 to 2010? Is the number of articles concerning this topic increasing or decreasing?
2. What research sample groups related to mobile and ubiquitous learning were selected in these articles from 2001 to 2010?
3. What research learning domains related to technology-based learning were adopted in these articles from 2001 to 2010? Did the learning domain shift between the first 5 years (2001–05) and the second 5 years (2006–10)?

Methods

This study examines the mobile or ubiquitous learning papers published in the Social Science Citation Index (SSCI) database from 2001 to 2010. Six major technology-based learning journals were selected to analyse the research trends, including the BJET, C&E, ETS, ETR&D, JCAL and IETI. These journals are widely accessed with high impact factors based on journal citation reports released by the ISI.

Two researchers who have had years of experience carrying out studies in this area were asked to filter the mobile and ubiquitous learning studies from the 3995 papers published by these six journals from 2001 to 2010. Only papers that were identified as being of the type 'articles' in the SSCI were considered; that is, publications such as 'book reviews', 'letters' and 'editorial materials' were all excluded from this study. We intend to include all of the papers published in these journals about Mobile and Ubiquitous Learning (MUL) without utilising other filtering criteria. It is expected that such a review can provide a more thorough view of MUL research. To be more precise in selecting the MUL articles from the candidate pool, the articles selected by the two researchers were compared to see if there were inconsistent selections, and if so, these selections were shown to the researchers for further discussion. After two iterations of filtering the papers and discussing the inconsistent decisions, a total of 154 document items concerning mobile and ubiquitous learning were selected.

Following this, four experts who have had years of experience doing research concerning technology-enhanced learning were invited to determine subcategories for the research samples and learning domains. After thorough discussion, the finalised subcategories of the research samples were identified, that is, 'elementary school', 'junior and senior high school', 'higher education', 'teachers', 'working adults' and 'non-specified'. Moreover, the learning domains were categorised into the following subcategories, including science (eg, physics, chemistry, and biology, medical and sport science), mathematics, language & art, social science, engineering (including computers), others and non-specified.

Results

Number of articles published

Figure 1 shows the number of mobile and ubiquitous learning articles published from 2001 to 2010. It can be seen that the research in this field increased at a fast pace from 2008. By dividing the past 10 years into two periods, we find that the number of papers published during the second 5 years (ie, 122) is nearly four times that of the first 5 years (ie, 32), implying that mobile and ubiquitous learning research has greatly advanced in the recent 5 years.

Research sample groups selected

Table 1 shows the distribution of the research sample groups selected in those mobile and ubiquitous learning studies. It is found that from 2001 to 2010, research samples in *higher education* were selected most (59), followed by *elementary school students* (41) and *high school students* (17). Only a few studies selected *teachers* (6), and *working adults* (6) as the research sample. By dividing the time period into the first and the second 5 years, we find that the sequence remains the same, implying that students from higher education and elementary schools have remained the major samples of mobile and ubiquitous learning research. Furthermore, this indicates that it is worth paying more attention to investigations of teachers and working adults' mobile and ubiquitous learning in the future.

Research learning domains

Table 2 shows the learning domains selected for the mobile and ubiquitous learning studies conducted in the first and the second 5 years. It can be seen that most studies did not involve any learning domain, instead, they mainly focused on the investigation of motivations, perceptions and attitudes of students toward mobile and ubiquitous learning in the two time periods (13 and 36) followed by 'engineering (including computers)' (2 and 20), 'language and art' (3 and 21) and 'science' (5 and 25).

As the number of articles published in the second 5 years is nearly four times that of the first 5 years, it is interesting to see what learning domains have been selected more often in the same

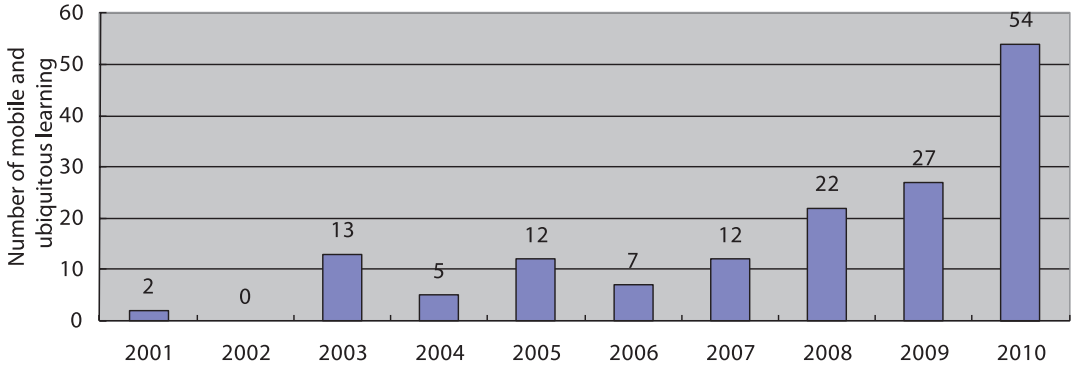

Figure 1: Number of mobile and ubiquitous learning articles published from 2001 to 2010

Table 1: Sample groups selected for mobile and ubiquitous learning studies from 2001 to 2010

Sample group	*Elementary school students*	*High school students*	*Higher education*	*Teachers*	*Working adults*	*Non-specified*
2001–05	7	3	9	2	2	9
2006–10	34	14	50	4	4	16
Total number of articles	41	17	59	6	6	25

Table 2: Research learning domains selected from 2001 to 2010

Learning domain	*Science*	*Mathematics*	*Language & Art*	*Social science*	*Engineering (including Computers)*	*Others*	*Non-specified*
2001–05	5	2	3	2	2	5	13
2006–10	25	4	21	9	20	7	36
Total number of articles	30	6	24	11	22	12	49

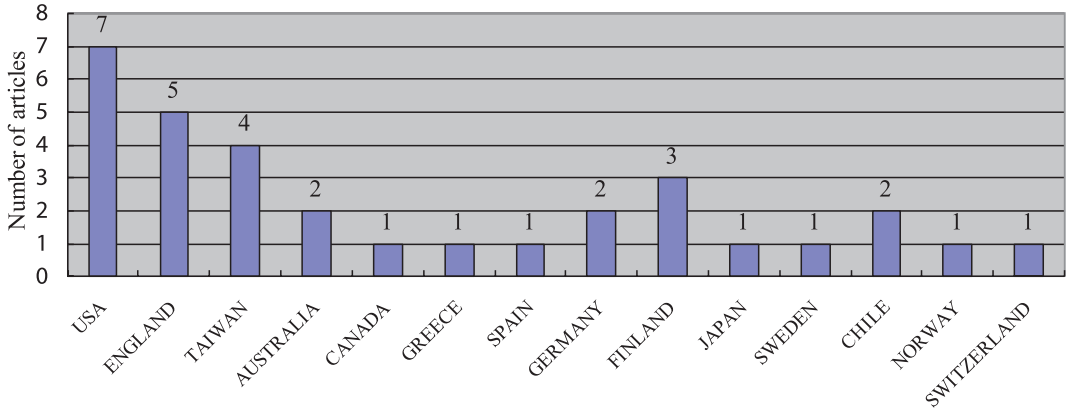

Figure 2: Major contributing countries of mobile and ubiquitous learning articles from 2001 to 2005

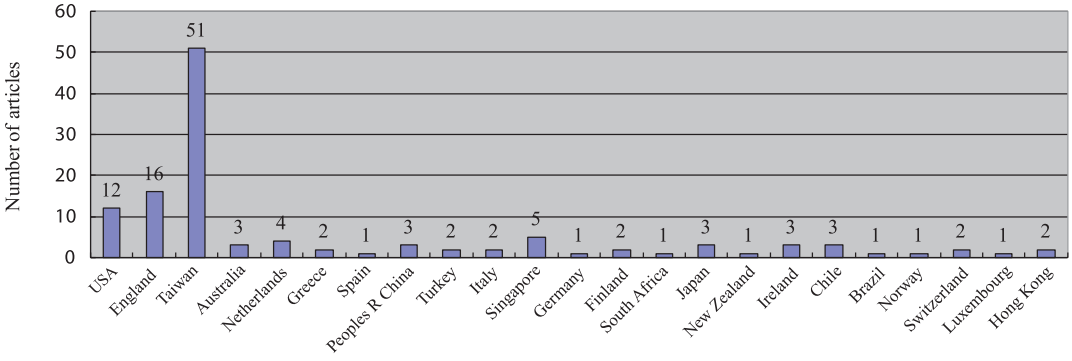

Figure 3: Major contributing countries of mobile and ubiquitous learning articles from 2006 to 2010

time periods. It is found that in comparison with the studies conducted in the first 5 years, studies focused on the learning domains of 'engineering (including computers)', 'arts and language', 'science' and 'social science' have significantly increased in the second 5 years by 10, 7, 5 and 4.5 times, respectively. On the other hand, the ratios for mathematics and other learning domains are relatively low; that is, 2 and 1.4, respectively.

Major contributing countries

Figures 2 and 3 present the major contributing countries of mobile and ubiquitous articles in the first and the second 5 years of 2001 to 2010. In the first 5 years, US authors contributed the most publications (7) followed by UK authors (5) and Taiwanese authors (4). However, Taiwan ranked number one over the second 5 years with an amazing number of publications (51) which is

clearly related to the initiation of the mobile and ubiquitous learning project (part of the second phase national program for e-Learning in Taiwan) in 2007 (Chang, Wang & Chen, 2009; Tsai, Chen & Chen, 2010). Moreover, it is interesting to know that more countries have contributed to the mobile and ubiquitous learning studies in the past 5 years, such as Singapore, Italy and Ireland.

Conclusion

This paper reviews the advancement of mobile and ubiquitous learning research from 2001 to 2010 based on the articles published in six major SSCI journals. It is found that the number of articles has significantly increased during the past 10 years; moreover, researchers from other countries have contributed to the related field in recent years. These findings could be good references for educators and researchers who plan to contribute to the relevant studies. Furthermore, as educators have emphasised the importance of situating students to learn in a real world environment (Lave & Wenger, 1991) and mobile and communication technologies that could be the key to supporting effective learning in the real world (Hwang, Kuo, Yin & Chuang, 2010; Peng *et al*, 2009), the analysis results could help policymakers in governments and researchers in professional organisations to allocate the necessary resources and make plans for supporting future research and applications.

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