British Journal of Educational Technology (2015)
doi:10.1111/bjet.12311

Research and trends in mobile learning from 1976 to 2013: A content analysis of patents in selected databases

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Abstract

Mobile learning has been a very popular topic in the past several decades. As more patents in this field have been submitted, the analysis of patents has surfaced as an important mechanism to understand trends, uses, targeted audiences and other aspects in the mobile learning space. Based on the CNIPR, USPTO, and Espacenet databases, this paper provides an analysis of mobile learning from 1976, when the first patent in mobile learning emerged, to 2013. One hundred thirty patents were analyzed from two dimensions: the instructional dimension (including target audience, situation and purpose) and the patent dimension (including technology and style). It was found that "students" was the most popular target audience; "out of class for education" was the most utilized situation; "provide more friendly peripheral service" was the primary purpose; "wireless, mobile and ubiquitous technologies for learning, pervasive computing for learning, u-computing in learning" were the most utilized technologies; and "system and method" was the most common style. Currently, patents in mobile learning are more inclined to provide personalized, contextualized, easily-retrievable, auto-updated and intelligent pushed learning content. Additionally, providing multipresentation, supporting seamless learning, adopting learner analysis, improving learner diversity and context awareness are becoming the characteristics of mobile learning patents.

Introduction

Mobile learning emerged at the end of the 20th century (Sharples, 2000) and has gained attention from researchers over time, particularly since the turn of the millennium with wider distribution of mobile devices. 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 any time" (Hwang, Tsai & Yang, 2008; Shih, Chu & Hwang, 2011). Researchers have made great achievements in different aspects of mobile learning, such as in mobile learning applications and systems (Hwang & Wu, 2014), the pedagogical frameworks for mobile learning (Laurillard, 2007; Park, 2011), learning strategies for mobile learning (Ralston, 2014), the value of mobile learning for students (Bogdanović, Barać, Jovanić, Popović & Radenković, 2014;

Practitioner Notes

What is already known about this topic

- The number of papers pertaining to mobile learning increased substantially between 2001 and 2010.
- Most studies on mobile learning have focused on effectiveness (whether mobile learning can benefit students) and system design.
- Mobile technologies have shown potential for future learning. However, learners may encounter psychological challenges when using mobile devices.
- Mobile learning patents provide valuable guidance to the practice and innovation in relevant research fields.

What this paper adds

- This study investigated the trends of patents related to mobile learning. One hundred thirty patents retrieved from CNIPR, USPTO and Espacenet were analyzed.
- Insights were made into the status of mobile learning patents from 1976 to 2013 according to teaching and patent dimensions.

Implications for practice and/or policy

- We clarified the current status of mobile learning patents and mobile learning development trends in the practical field.
- Personalized, contextualized, easily-retrievable, auto-updated and intelligent learning contents should be provided for learners.
- Content presentation tends to be multiterminal and timely.
- People in this field should pay particular attention to learner analysis and context awareness.

Hwang, Huang, Shadiev, Wu & Chen, 2014) and mobile learning in teacher education (Aubusson, Schuck & Burden, 2009; Ekanayake & Wishart, 2014; Foulger *et al*, 2013).

Some researchers have also conducted reviews of previous studies to make a clearer understanding of mobile learning (Frohberg, Göth & Schwabe, 2009; Hwang & Tsai, 2011; Hwang & Wu, 2014; Lam, Yau & Cheung, 2010; Wu *et al*, 2012). In most research, researchers obtain papers from selected books, journals and conference proceedings. However, as an important form of original research achievements, patents have not attracted attention from researchers compared with monographs, papers, conference proceedings, etc.

Mobile learning patents provide important guidance for practitioners and researchers in relevant fields, so it is significant to analyze them. Mobile learning involves various technologies, such as mobile computing technology, network technology and multimedia technology. As a result, to make mobile learning widespread and efficient, governments, companies and universities should work together to promote the development of mobile learning. Clarifying the current status of patents in the field is a first step.

This study intends to investigate the trends of mobile learning patents.

Three major databases were selected for analysis: China Intellectual Property Right Net (2014) (CNIPR), United States Patent and Trademark Office (2014) (USPTO) and European Patent Office (2014) (Espacenet). The following research questions are addressed in this paper:

1 What is the status of mobile learning patents retrieved from CNIPR, USPTO and Espacenet from 1976 to 2013?

2 What is the status of mobile learning patents in the instructional dimension?
  2.1 What are the target audiences of mobile learning patents from 1976 to 2013, and how do the target audiences shift between the early period (1976–2004) and the current period (2005–13)?
  2.2 What situations are included in the mobile learning patents from 1976 to 2013, and how do the situations change between the early period (1976–2004) and the current period (2005–13)?
  2.3 What purposes are included in the mobile learning patents from 1976 to 2013, and how do the purposes vary between the early period (1976–2004) and the current period (2005–13)?
3 What is the status of mobile learning patents in the patent dimension?
  3.1 What technologies are utilized in the mobile learning patents from 1976 to 2013, and how do the technologies shift between the early period (1976–2004) and the current period (2005–13)?
  3.2 What styles of mobile learning patents exist from 1976 to 2013, and how do the styles change between the early period (1976–2004) and the current period (2005–13)?

Review of mobile learning and mobile learning patents

In the past several decades, various studies have been conducted regarding mobile learning. Li, Ogata, Hou, Uosaki and Mouri (2013) demonstrated that learners benefited from mobile learning for capturing input and for archiving a learning log; furthermore, context-based recommendations and learning-habit-based prompting also motivated learners to study more. McConatha, Praul and Lynch (2008) conducted an empirical evaluation of the effectiveness of mobile learning in a college and found that it was more conducive to students' learning outcomes compared with traditional learning. In addition, mobile learning has shown to benefit teachers as well. Researchers found that an increasing number of preservice teachers were accessing resources on mobile devices (Hossain & Quinn, 2013). Mobile tools may be conducive to preservice teachers' understanding and developing of new literacies (Husbye & Elsener, 2013), exploring real-world physical education (McCaughtry & Rocco Dillon, 2008) and conducting scientific investigations (Gado, Ferguson & van t Hooft, 2006).

Researchers have also reviewed papers of mobile and ubiquitous learning from different perspectives. For example, Hwang and Wu (2014) investigated the application and impact of mobile technology-enhanced learning and found that mobile learning was promising in improving students' learning achievements, motivations and interests. Hwang and Tsai (2011) analyzed the papers published in six major SSCI journals regarding mobile and ubiquitous learning from 2001 to 2009. They found that the volume of papers had significantly increased and that researchers from different countries had contributed differently to the field. Wu *et al* (2012) concluded that most studies of mobile learning focused on its effectiveness, followed by mobile learning system design. Surveys and experiments were used as the primary research methods (Wu *et al*, 2012). The significant growth of mobile and ubiquitous learning between 2005 and 2009 was one of the major findings by Hsu *et al* (2012).

However, there are some issues in mobile learning that need to be addressed. Terras and Ramsay (2012) identified five important psychological challenges learners may encounter when using mobile devices for learning: the context-dependent nature of memory, the finiteness of human cognitive resources, distributed cognition and situated learning, metacognition, and individual differences. Koszalka and Ntloedibe-Kuswani (2010) reviewed the safe and disruptive learning potential of mobile technologies and a review of a broad range of investigative cases was presented and critiqued. Frohberg *et al* (2009) provided a critical analysis of mobile learning projects published before the end of 2007 and briefly summarized the exemplary projects for each cat-

egory. Moreover, survey research has shown varied results. Thomas, O'Bannon and Bolton (2013) indicated that the majority of teachers support the use of cell phones in the classroom and identified students' engagement and motivation as the main benefits, while O'Bannon and Thomas (2014) stated that teachers' age mattered in their perceptions of using mobile phones in the classroom. The results highlight that there is still much to learn about and explore in the use of mobile learning.

Although patents in mobile learning can tell much about the trends in this field, few researchers have paid attention to the analysis of patents. Such an analysis would offer a unique lens to understand how individuals conceptualize mobile learning and may offer unique insights into how to advance learning and therefore benefit the development of this field.

Methods

Samples

This study examined 130 patents which were relevant to mobile learning from 1976 to 2013.There is a delay between the time filed and the time published of patents. Therefore, some patents may not be subject to this analysis, such as those that were filed in 2012 and 2013. Three databases were selected: CNIPR, USPTO and Espacenet. These databases are widely accepted and recognized as authoritative in the compilation of resources for the social sciences.

The patents mentioned in this paper were retrieved from the three databases using specific keywords. The keywords included "mobile learning," "mobile education," "m-learning," "ubiquitous learning" and "miniature learning." After the retrieval process, researchers retained 145 patents after eliminating duplicates. When analyzing the patents, researchers found that 15 items did not fit the scope of the study. Therefore, 130 patents were used as research samples.

Data coding and analysis

This study used 130 patents to create a detailed view of the trends of mobile learning from the aspect of patents. The patents were classified into different target audiences, situations, purposes, technologies and types. It should be noted that many patents can be used by different audiences or in more than one situation. In those cases, all target audiences or situations were labeled.

The code table was designed by three postgraduate students of educational technology who formerly conducted an extensive literature review of papers and patents on mobile learning. The table was then revised according to the suggestions of three experts in mobile learning.

The coding process was performed manually by the researchers. The postgraduate students categorized the patents based on the aforementioned categories (target audiences, situations, purposes, technologies and styles). However, one of them did not finish all of the items and his codes were excluded. The results of the other two researchers were compared. The results reached a reliability of 0.865 (reliability, *R*, was counted according to the formulas below). Three researchers discussed the items and after some debate, consensus was reached on the categorization for all the items and the results were used in this paper.

$$\mathrm{K_{AB}} = 2\times M/(N_{\mathrm{A}} + N_{\mathrm{B}}), \mathrm{R_{AB}} = 2\times K_{\mathrm{AB}}/(1+(2-1)\times K_{\mathrm{AB}})$$

A, B = two researchers who coded the patents separately
M = the number of items that have the same codes by A and B
K_{AB} = the agreement of A and B
N_A = the total number of items coded by A
N_B = the total number of items coded by B
*R*AB = the reliability of A and B

Results

Research question 1: What is the status of mobile learning patents retrieved from CNIPR, USPTO and Espacenet from 1976 to 2013?

Figure 1 shows the number of mobile learning patents applied from 1976 to 2013. In 1976, Wilson (1978) submitted a patent application named "Rigid mobile cabinet for audio-visual aids," which was considered the first patent application in the mobile learning field. Although the term "mobile learning" had not appeared at that time, audio-visual teaching had reached a level of maturity 30 years earlier during World War II, when armies and industries needed to be trained effectively and efficiently. Audio-visual materials were widely used in that effort. It can be assumed that in the 1980s, because of the need of training in different places, audio-visual materials needed to be mobile, causing the mobile cabinet invented by Wilson to be of great practical significance.

The data show that the number of mobile learning patents increased most noticeably since 2000. This increase coincided with the time frame when the concept of mobile learning was initially put forward (Sharples, 2000). From 2000 to 2004, mobile learning was in its exploratory period, when researchers mainly focused on mobile learning theory and the early uses of mobile technology in learning. In addition, the number of patents was relatively few. From 2005 to 2011, along with the development of mobile learning theory, mobile technology, wireless Internet technology and handheld devices, mobile learning research experienced an upsurge in use and popularity. This is consistent with former research, which states that the applications of mobile learning have been significantly increased since 2008 (Hwang & Tsai, 2011; Tsai & Hwang, 2013). Various patents (eg, mobile learning devices, mobile learning systems, learning analysis, etc.) emerged during this period, which indicated the boom of mobile learning, and continued providing a good environment for the development of mobile learning. By 2012, the number of patents fell slightly. We are not sure if this result can be attributed to the fact that some patents of 2012 and 2013 have not been published yet or if there are some other reasons.

Figure 2 presents the major distribution of countries that filed mobile learning patents from 1976 to 2013. The number of patents applied by the USA, South Korea, China, Taiwan and Japan was 60, 26, 25, 10 and 6, accounting for 46%, 20%, 19%, 8% and 5% respectively. These numbers largely corresponded with that of Hwang and Tsai's (2011) research. In their research, the major

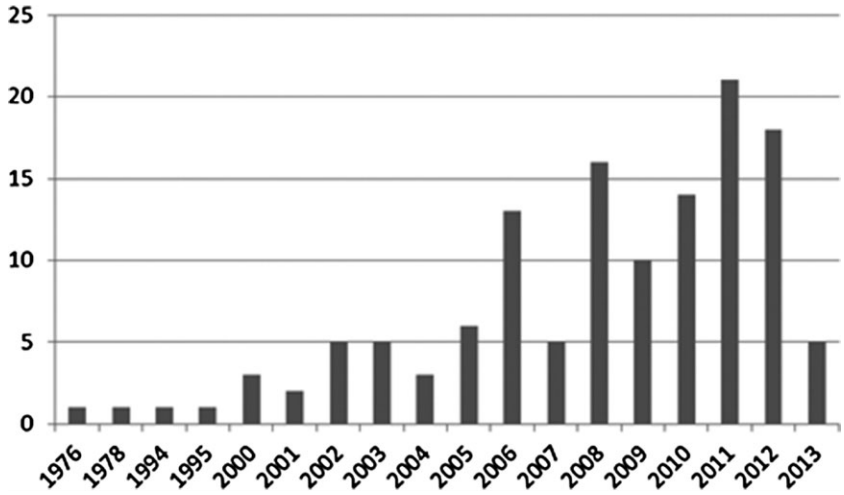

Figure 1: Number of mobile learning patents from 1976 to 2013 (n = *130)*

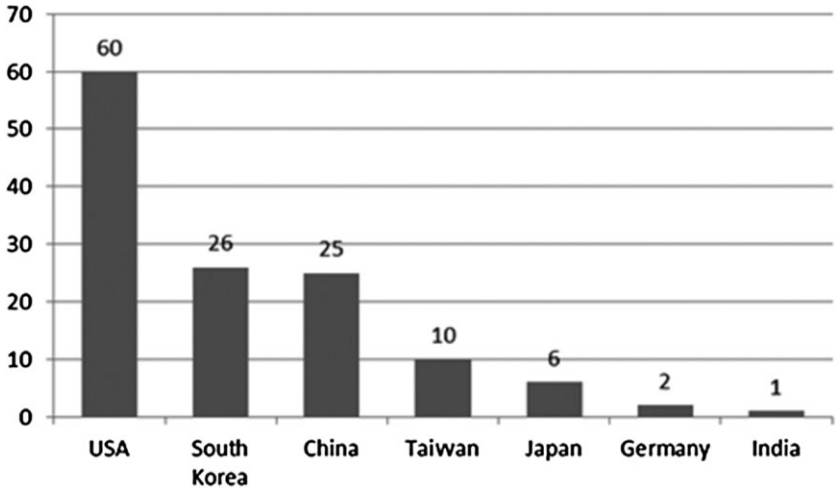

Figure 2: Major distribution countries of mobile learning patents from 1976 to 2013 (n = 130)

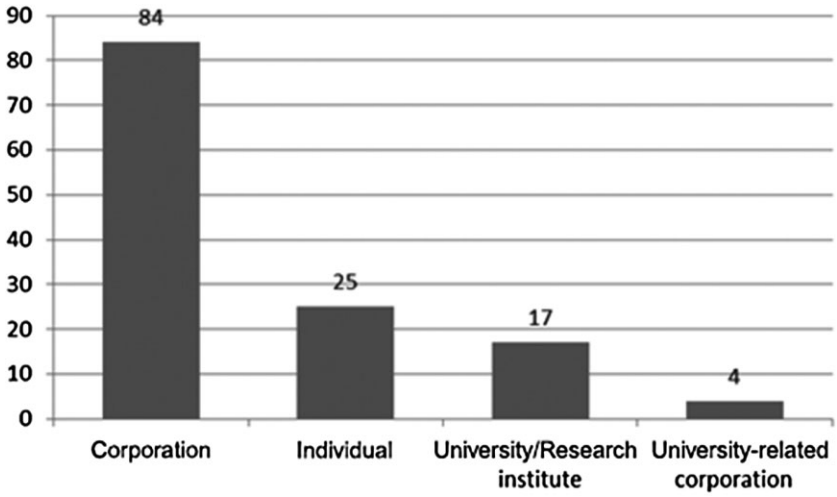

Figure 3: Major distribution ownership of mobile learning patents from 1976 to 2013 (n = 130)

contributing countries or areas of mobile learning papers during 2006 and 2010 were Taiwan, England, USA, Singapore and the Netherlands. The correspondence shows that as different forms of research production surfaced, there were similarities between literature and patents. Indeed, it is mobile learning theory that supports the research production in the mobile learning field globally. Nevertheless, the results differ slightly because of the difference between literature and patents and the discrepancy of people's awareness of the intellectual property rights protection and economic factors.

Figure 3 presents the major distribution ownership of mobile learning patents from 1976 to 2013. The number of patents owned by corporations, individuals, universities and research institutes, and university-related companies (usually in very close collaboration with universities) was 84, 25, 17 and 34, accounting for 65%, 19%, 13% and 3% respectively, of all these 130 patents. The results also showed that corporations own much more patents in mobile learning

than individuals, universities or research institutes. Moreover, patents were largely distributed in enterprises with more developed technologies, such as International Business Machines Corp., which has nine mobile learning patents; Seven Networks Inc., which has eight patents; Research In Motion Ltd., which has four patents; and Google Inc., which has three patents. Universities and research institutes applied for mobile learning patents at a later time and owned comparatively fewer patents in the mobile learning field. However, universities and research institutes had become another important applicant of mobile learning patents after successfully submitting 11 mobile learning patents.

Research question 2: What is the status of mobile learning patents in the teaching dimension?

Target audience

Figure 4 shows the target audiences of mobile learning patents. From 1976 to 2004, "students" (13) were the main subjects of mobile learning processes, followed by "enterprises" (11) and "supervisors and service providers in school" (3). "Parents" were targeted as an audience only once. From 2005 to 2013, mobile learning patents focusing on student audiences experienced rapid growth (77) and were still the focal point of mobile learning patents, followed by "enterprises" (41), "teachers" (16), "supervisors and service providers in school" (9) and "parents" (2). Because of the complexity of mobile learning audiences, six patents were not classified into any of the items above.

Situation

The distribution of applicable situations is shown in Figure 5. Because mobile technologies can be used anywhere, various situations were covered by these patents. Nevertheless, school was still the most popular applicable situation for mobile learning patents. The data showed that from 1976 to 2004, "out of class for education" was the most popular situation in which mobile learning occurred (15), followed by "in class for education" (11), "training" (9) and "support for education (eg, teaching management system)" (6). No patent was coded as "other." From 2005 to 2013, "out of class for education" (77) was still the most common situation and "in class for education" (65) was not far behind; "training" (21), "other" (18) and "support for education (eg, teaching management system)" (15) were less common. All categories experienced large increases between the first and second periods.

Purpose

We analyzed the purpose of mobile learning patents. The results are displayed in Figure 6. "Provide more friendly peripheral service" (11) and "support personalized, contextual, easily-

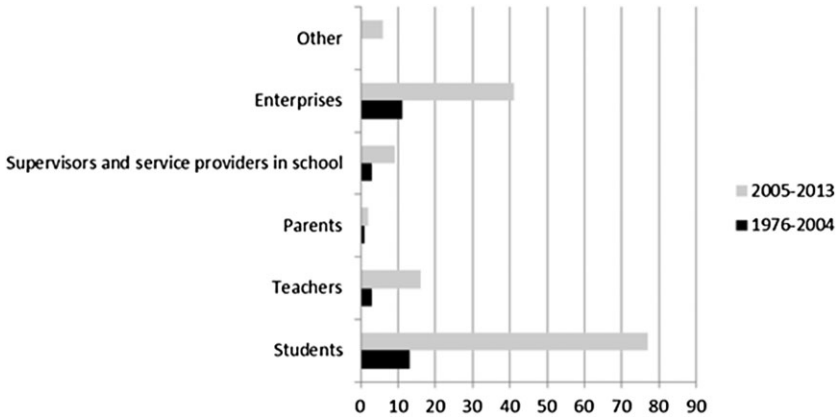

Figure 4: Distribution of target audiences

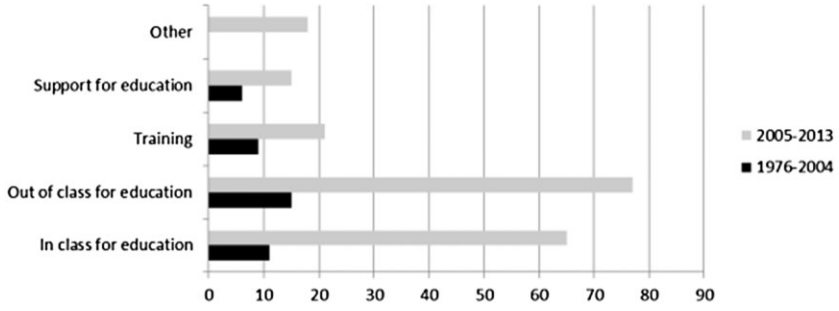

Figure 5: Distribution of applicable situations

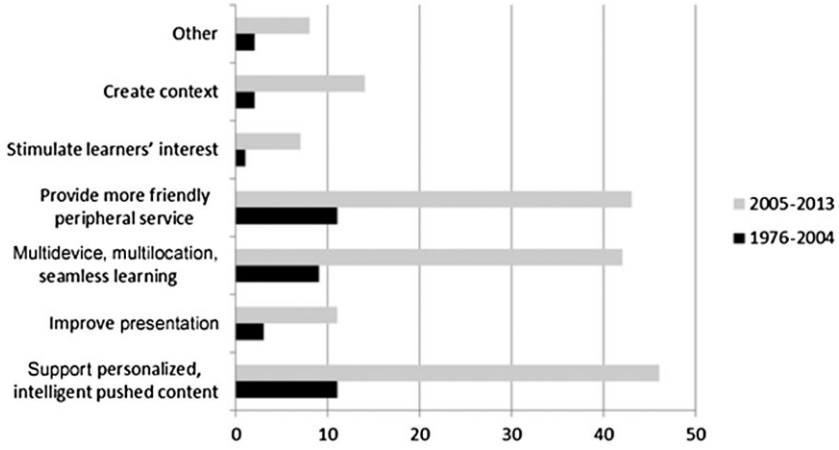

Figure 6: Distribution of purposes

retrievable, auto-updated, intelligent pushed content" (11) were the main purposes of mobile learning, followed by "multi-device, multi-location, seamless learning" (9), "improve presentation" (3), "create context" (2), "other" (2) and "stimulate learners' interest" (1). It can be concluded that researchers had not paid enough attention to stimulating learners' interest or to creating context before 2004. However, from 2005 to 2013, more attention was paid to "create context" (14) and "stimulate learners' interest" (7). "Support personalized, contextual, easily-retrievable, auto-updated, intelligent pushed content" (46) was the most common purpose, followed by "provide more friendly peripheral service" (43), "multi-device, multi-location, seamless learning" (42), "improve presentation" (11) and "other" (8).

Research question 3: What is the status of mobile learning patents in the patent dimension?

Technology

Figure 7 shows the distribution of technologies used in these patents. From 1976 to 2004, more than half of the patents involved "wireless, mobile and ubiquitous technologies for learning, pervasive computing for learning, u-computing in learning" (16), followed by "learner analysis" (7), "other" (5) and "context-aware u-learning" (2). From 2005 to 2013, "wireless, mobile and ubiquitous technologies for learning, pervasive computing for learning, and u-computing in learning" (96) were still the most frequently used technologies, followed by "learner analysis" (22), "other" (19) and "context-aware u-learning" (12).

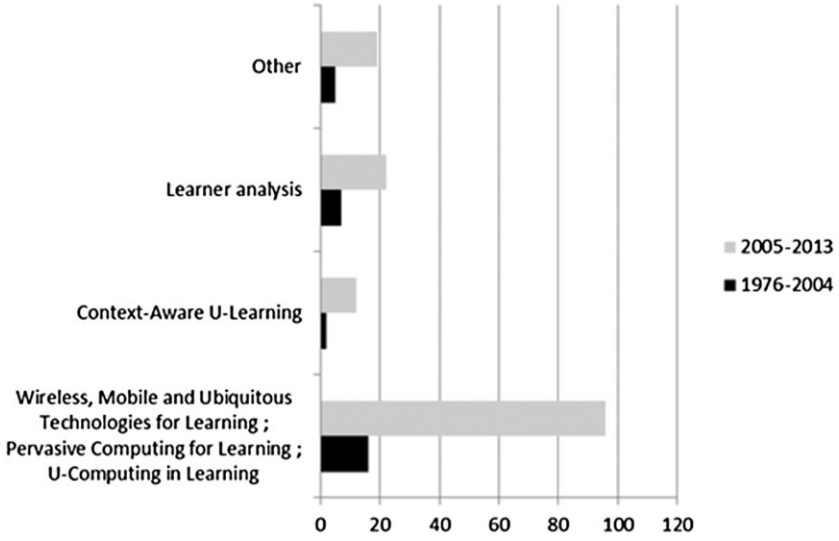

Figure 7: Distribution of technologies

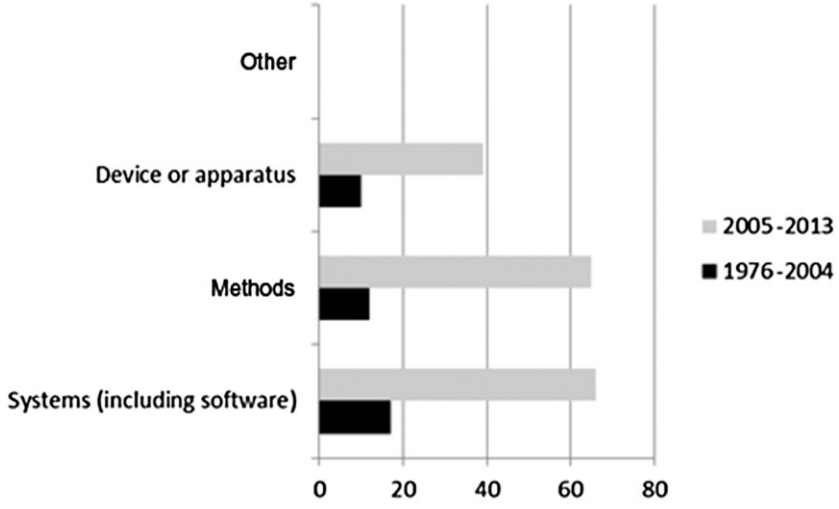

Figure 8: Distribution of formats

Style

Figure 8 shows the different styles of patents in mobile learning. Most of the patents included both systems and methods. From 1976 to 2004, "systems (including software)" (17) was the leading style in mobile learning patents, followed by "methods" (12) and "device or apparatus" (10). From 2005 to 2013, "systems (including software)" (66) still attracted the most attention of the researchers in the mobile learning field, followed by "methods" (65) and "device or apparatus" (39). No patents were ruled out of this classification.

Discussion

After analyzing the 130 patents on mobile learning from 1976 to 2013, the following trends emerged. Overall, the number of patents in mobile learning has been on the rise since the turn of

the century, which is consistent with Liu and Hwang's (2010) assertions. They predicted that more technology-based learning would occur with newly developed devices or concepts. This prediction is applicable for patents in mobile learning as well. Although the patents had decreased in 2013 in this study, this decrease was likely due to the delay between the time filed and the time published of patents. The majority of the patents belonged to enterprises. This concentration can be explained by the presence of several large companies in the USA, such as International Business Machines Corp., Seven Networks Inc. and Google Inc. These companies own a large share of the mobile learning patents.

Additionally, we found that the learning content became more personalized. Increasingly, students could have access to personalized service in different intelligent learning systems according to their own learning abilities and learning purposes (Zhao, Anma, Ninomiya & Okamoto, 2008). The term "personalized service" can be reflected in the following aspects: personalized choice of learning content, personalized organization of learning form, personalized presentation of learning materials and personalized interaction with devices. After the detail content analysis of the patents, we found that students' learning information, such as learning behaviors, learning progress, the evaluation of learning process and other data, could be collected by the mobile learning systems (Takamatsu, Hayashi & Mizunashi, 2000; Yamane, 2002). According to this information, the systems can provide students with personalized learning service. Some other patents can sense learners' location and context information with the help of context identification modules, like Quick Response code (QR) or Radio Frequency Identification (RFID) (Kim, 2009; Li, 2011). With this method, the mobile learning system can provide context-based learning content so as to promote students' learning. What is more, some patents provide methods for more structured content organization and presentation, such as labeling the content (Seiichi, 2008).

This trend can be explained by learner-centered theory. The theory's key idea is that people learn best when engrossed in a topic and motivated to seek out new knowledge and skills they need (Norman & Spohrer, 1996). Education primarily focuses on "students" and mobile learning patents share this characteristic. Ninety patents take "students" as their target group. An increasing number of mobile or ubiquitous learning activities have been conducted in the field (Chu, Hwang, Huang & Wu, 2008; Tan, Liu & Chang, 2007). As for the field of mobile learning patents, the majority of patents are more suitable for the "out of class for education" situation. Content recommendation is of greater importance because users are often looking for specific knowledge rather than general-purpose websites (Liang, Lai & Ku, 2007). Most patents of mobile learning indicate the trend to "support personalized contextual, easily retrievable, auto-updated, intelligent pushed content."

Moreover, multiple devices and multipresentation make mobile learning easier. The learning resource can be displayed better. For example, in order to make up the deficiency of the small screen of PAD, a projector is built-in a PAD, so the content can be projected to PCs or TVs (Zhuo, 2010). Additionally, learning resources and logs can be adapted to different devices seamlessly. For example, no matter what kind of device one uses, the learning logs can be recorded and uploaded to the server. Once there are some different files between any device and the server, the files on the device will update automatically (Messner, Schwartz & Varghese, 2010). Learning logs stored on the server can also be shared by different devices of learners. Even teachers' behaviors, voices, the blackboard writing and the content on the interactive whiteboard can be recorded and can be broadcast to different devices (Lin, 2012). So students are able to learn anywhere with the most appropriate devices without considering saving their learning logs. In other words, students can learn seamlessly.

The audiences of mobile learning tend to be diverse. We found that the target audiences of the patents have been extended from students to a blended group, including farmers (Beijing

Academy of Agriculture and Forestry, 2012), enterprise employers (Lin, 2006) and students of vocational education (Kuwahata, 2002). Mobile learning is quite attractive and beneficial to adult learners as it enables adults to learn flexibly relative to time and to place. These patents may also function to support career development. It will be conducive to conducting lifelong learning. Moreover, some patents aim to link students, teachers and parents together, and report students' location and learning information to their parents and teachers (Ahn *et al*, 2001). Thus, parents and teachers can work together to improve the quality of education.

Mobile and wireless communication technologies can play an important role in the evolution of education (Liu & Hwang, 2010). This may explain why a majority of mobile learning patents involve the "wireless, mobile and ubiquitous technologies for learning, pervasive computing for learning, and u-computing in learning" technology.

Conclusion

This paper reviewed the advancement of patents in mobile learning from 1976, when the first patent in mobile learning emerged. One hundred thirty patents from the CNIPR, USPTO and Espacenet databases were analyzed. It was found that the number of patents had significantly increased since 2000. It was also found that, over time, these patents were more inclined to provide personalized, contextualized, easily retrievable, auto-updated and intelligent pushed learning content. The presentation tends to be multiterminal and timely. The patents provided seamless learning with any device, anywhere. Learner analysis has received more attention since 2005. The diversity of learners has been taken into consideration more frequently in patents, and more friendly service is provided as well. Context awareness in education will attract more attention. Universities or research institutes will likely play an increasingly important role.

By reviewing the latest patents, we found that there were some issues worth noticing in the future: learning interactive systems, learning support systems based on cloud computing, and portable learning devices which may facilitate learning and teaching (Lan, Si & Xie, 2014; XingTai University, 2014). As for the learning interactive systems, these patents mainly provide methods which support the interaction among students and teachers (Cao, Mao & Zhou, 2014; Su, 2014; Yu, Cai & Wang, 2014). This will benefit both teaching and learning. Cloud computing becomes more and more general so students have better access to learning resources and services (Shaanxi Radio and TV University, 2014; Wang *et al*, 2014). What is more, the application of cloud platforms in education can help teachers collect students' information during their learning processes and give them feedback efficiently. Finally, portable devices should be afforded and used with greater ease and appeal.

Acknowledgements

Our work is supported by the Fundamental Research Funds for the Central Universities (705-105570GK), Joint Laboratory for Mobile Learning, Ministry of Education-China Mobile Communications Corporation. We also thank Professor Kirk Perris who proofread the paper.

Statements on open data, ethics and conflict of interest

Open data statement

We accessed all the patents from 3 open patent databases: CNIPR, USPTO and Espacenet, using the keywords of "mobile learning," "mobile education," "m-learning," "ubiquitous learning" and "miniature learning". All the patents were classified according to the code table (target audiences, situations, purposes, technologies and types). Two researchers finished coding all the patents and reached a reliability of 0.865.

Ethical considerations

This research was carried out under the ethical guidelines. In this paper, the subjects were patents and all patents were open. We analyzed the content of the patents so no ethical issues existed.

Conflicts of interest statement

No conflict of interest exits in the submission of this manuscript, and the manuscript is approved by all authors for publication. I would like to declare on behalf of all the co-authors that the work described is original research that has not been published previously, and not under consideration for publication elsewhere, in whole or in part.

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