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THE PITFALLS OF MOBILE DEVICES IN LEARNING: A DIFFERENT VIEW AND IMPLICATIONS FOR PEDAGOGICAL DESIGN

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ABSTRACT

Studies have been devoted to the design, implementation, and evaluation of mobile learning in practice. A common issue among students' responses toward this type of learning concerns the pitfalls of mobile devices, including small screen, limited input options, and low computational power. As a result, mobile devices are not always perceived by students as beneficial tools for their learning. Such perception undermines the use of mobile devices in learning and dampens teachers' interest in adopting mobile learning. This study tackles this issue and proposes that contextualizing the use of mobile devices can promote students' attitudes toward the use of mobile devices in learning. In other words, the use of mobile devices in learning should be in conjunction with the ambient artifacts where the user is and corresponding experience may provide the user with a positive perception toward the use of mobile devices. The proposed approach is evaluated by a sample practice to obtain preliminary supporting evidence. Further discussion is made on some innovative designs of mobile learning practices. This study is to provide a different view of mobile devices' pitfalls in learning and suggests that, relying on appropriate design, these pitfalls can be overcome to embrace a broader spectrum of mobile learning practice designs.

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INTRODUCTION

The past few years have witnessed the development of a substantial body of literature reporting pilot projects on learning with mobile devices, and a surge of conferences pertaining to mobile learning research. Some researchers claimed that the portability and accessibility of mobile devices would allow learners to access learning materials and to communicate with their teacher and peers with less time and space constraints (Chinnery, 2006; Nah, White, & Sussex, 2008; Rosell-Aguilar, 2007). However, there has been some usability issues of mobile devices reported. For example, when learners receive contents on their mobile devices, they may find it difficult to interact with such contents on a tiny screen and in circumstances that they do not associate with learning (Kukulska-Hulme, 2009). Christopher and Goolsbee (2010) also pointed out that while mobile devices enable convenient access to large amounts of information and data, an important question is whether gathering information from such small screens would result in a cognitive trade-off in subsequent performance. They further questioned whether learning and understanding is sacrificed for enhanced personal flexibility, and whether such trade-off is acceptable or of any worth.

Levy and Kennedy (2005) argued that the widespread acceptance of mobile devices in non-learning contexts does not necessarily mean that they will be valued in educational contexts. In addition, merely providing access to hardware and software does not necessarily guarantee effective integration of IT into an educational setting without the learners' inclination to use the technology (Selwyn, 1997). Intention to use a technology is an individual's perceptions about the characteristics of the target technology as explanatory and predictive variables for acceptance behavior (Selim, 2003). In learning, usability serves as one of the important factors affecting learners' attitudes toward using that technology tool in learning, and thereafter their behavioral intentions and actual tool use (Davis, 1989). Usability issues prevent learners from engaging fully with their educational tasks in spite of careful designs and preparations (Kukulska-Hulme, 2007). As Wagner (2005, p. 50) pointed out: ". . . complicated key controls and difficult-to-read screen presentations will be tolerated only under certain very limited conditions. The rest of us are not willing to risk having a bad experience." Hence, usability of mobile devices needs to be addressed to ensure its successful application to learning. For tackling this issue, this study proposes that contextualizing the use of mobile devices may provide the user with a positive perception toward the use of mobile devices. This proposal will be evaluated by a sample practice to obtain preliminary supporting evidence. Further discussion will be made on how to treat the pitfalls of mobile devices when designing a learning practice and aims to provide a different view of the pitfalls of mobile devices in learning.

LITERATURE REVIEW

The concept of usability was originally developed within the discipline of Human-Computer Interaction and applied to the interaction between a user and a computer. Usability is about making systems easy to learn and easy to use (Preece, Rogers, Sharp, Benyon, Holland, & Carey, 1994; Zhang & Adipat, 2005). Responses to the usability of mobile devices in learning often refers to their inherent limitations: tiny screen size, low computational power, small battery capacity, limited input interface and narrow network bandwidth (Chen, Chang, & Wang, 2008; Corlett, Sharples, Chan, & Bull, 2005, Kukulska-Hulme, 2009, Thornton & Houser, 2005). Albers and Kim (2001) highlighted three items that affect user access to information via handheld devices. They include:

1. greater difficulty in reading text on a mobile device screen than on paper;
2. limitations in presenting graphical information with complex image and of large size; and
3. increased challenges to interactivity without a mouse and a keyboard, as well as small screen size.

Several studies have explored and validated various means to improving the usability of mobile devices in learning. The first type of means is technology-oriented. For example, learning contents are designed to be studied using only arrow keys, thus eliminating the need of typing (Morita, 2003). Jones, Buchanan and Thimbleby (2003) further suggested that vertical rather than horizontal scrolling might be adopted. As to how the content is scrolled, the method of Leading, or the Times Square Format, scrolls the text on one line horizontally across the screen while Rapid Serial Visual Presentation presents the text as chunks of words or characters in rapid succession at a single visual location (Öquist & Goldstein, 2003). Albers and Kim (2001) proposed dragging a stylus up and down on the screen. Finally, when the usability issue is related to the diversity of mobile device, Huang, Kuo, Lin, and Cheng (2008) designed a context-awareness synchronous learning system with fuzzy weighted average algorithm, and provided various content styles to make learning contents appropriate for display on different learning devices.

The second type of means is pedagogy-oriented. Thorton and Houser (2002) recognized that the small screen size on mobile devices was deemed unsuitable for learning new contents. However, they valued the effective use of mobile devices for review and practice, and suggested e-mailing students short mini-lessons in discrete chunks that could be easily read on the tiny screen. In this way, learners are able to complete an activity within a short time and then proceed to the next when time is available. For example, in language learning, vocabulary items can be presented through short definitions and examples that suit the screen dimensions and general handling capabilities of a mobile phone (Kennedy & Levy, 2008).

The third type of means takes an individual learner's cognitive capability into consideration. Using the concept of Learning Content Representation (LCR), Chen, Hsieh, and Kinshuk (2008) addressed the issue of content adaptation in mobile language learning environments. In their study, two dimensions have been identified to provide a promising solution: instructional strategies (LCR types: written annotation and pictorial annotation), and learners' cognitive models (verbal and visual short-term memory). They also showed that, for learners with lower verbal and higher visual ability, the learning content with pictorial annotation is more helpful in a mobile language learning environment.

However, the above means to improve the usability of mobile devices in learning concern mainly overcoming the limitations of the mobile device and content adaptation. Little attention has been paid to the purpose of using the mobile device for finishing a task. In addition, the use of mobile devices is different from that of computers. Computer use is usually confined to a fixed location for interacting with multimedia information displayed on the computer screen. Physical movements and changing variables of users (Kjeldskov & Stage, 2004) and the small scale and ubiquitous nature of mobile devices (Hagen, Robertson, Kan, & Sadler, 2005) contributed to the complexity and challenges of mobile human-computer interaction. Indeed, usability testing for mobile and handheld devices is not as well understood as that for desktop applications (Goodman, Brewster, & Gray, 2004). The so-called mobile usability is regarded as an emerging specialism within the more general field of usability and has also been evolving (Kukulska-Hulme, 2007). As our conceptions and understanding of mobile learning deepen, existing knowledge and frameworks gained in computer-assisted learning (CAL) might no longer be adequate (Vavoula & Sharples, 2009). This study argues that the discussion about usability of mobile devices should take into consideration both the context in which the mobile devices are used and the reasons why they are used.

Finally, Jones and Issroff (2007) pointed out that despite the prevalence of usability problems, the extensive use of mobile devices suggests that there exist strong incentives inducing people to persist in using their mobile devices. This not only leads Jones and Issroff (2007) to investigate the motivation of informal learners in using mobile devices, but also inspires this study to explore ways to improve the usability of mobile devices in learning. Moreover, numerous successful mobile learning practices have been reported and students have shown satisfaction with the use of mobile devices (Chen, Kao, & Sheu, 2003; Corlett et al., 2005; His, 2003; Huang et al., 2008). Previous findings seem to reveal that the usability of mobile devices is not an unsolvable issue. Hence, this study attempts to explore it further and gain better understanding.

CONTEXTUALIZING THE USE OF MOBILE DEVICES

Some of the studies on mobile technologies tend to focus only on the capabilities or limitations of the device, and the device itself as a point of focus or distraction (Reynolds, Walker, & Speight, 2010). If the design focus is on the device feature of portability and anytime, anywhere connectivity, then it is necessary to compromise with the inherent limitations of small screen and limited input options. In most cases, such design would contribute to pitfalls of mobile devices in learning. This study suggests that the design should go beyond the mobile device and create new features that could compensate the intrinsic drawbacks. For example, Harris and Park (2008) demonstrated how podcasting can be employed to help dyslexic students in a dyslexia support program. Lee, McLoughlin, and Chan (2008) used iPod as a vehicle for disseminating learner-generated content, and focused on its value for students' knowledge-creation. Moreover, infrared (IR) tag in a social participatory game does not require the input of a mobile device (Wilensky & Stroup, 1999; Zurita & Nussbaum, 2004) when the digital information is synthesized, summarized, and displayed in a shared big screen. Their applications in mobile learning are not much affected by the limitations of mobile devices.

Instead of figuring how to use mobile devices in learning, we should examine the pedagogy and consider how mobile devices would be adopted to support the pedagogy. With appropriate design, the inherited limitations of mobile devices should not be a concern in that adoption. On the contrary, if the design is technology-centered, the limitations will pose problems because the mobile device is adopted solely for its feature of anytime, anywhere communication. The idea of innovative design may help in this discussion. Educational innovation is a transformation which may change students' learning routines, including content, cognitive processes, and problem solving (Hughes, 2005). The design should lead to the mobile devices being used in a way not as before. In the earliest studies, the design of mobile devices primarily focuses on the technical features of portability and accessibility, inherently accompanied the limitations of tiny displays and limited input during the learning process. The new design should not follow that rationale.

This study proposes contextualizing the use of mobile devices in learning to improve its usability. The contextual use of mobile devices means to have the digital data on the mobile device, the artifacts around the learner, and the arranged learning activities structured to provide users with meaningful learning experiences. The meaningfulness of learning experiences thus seems to compensate for the distraction induced by the limitations of mobile devices. For example, in a museum, the mobile device should not only be viewed as a tool for providing digital information anywhere anytime; within the context of a single visit, it also serves as both a practical tool for navigating the museum and a

cognitive tool for making meaning (Reynolds et al., 2010). The idea here is in line with the argument of Jones and Issroff (2007) that learning-in-context is viewed as a starting point for exploring the motivational pull of using mobile devices. Sagarra and Zapata (2008) further suggested that participation in courses in which technology is part of the curriculum can shape attitudes toward technology tools. If mobile device-mediated learning can provide a positive experience to students and motivate them to use the device, their perception about the usability of mobile devices in learning may be enhanced. Hence, when tackling the challenging issue of usability of mobile devices, researchers should focus on the contextual use of mobile devices.

As to the design issue, Kjeldskov and Graham (2003, p. 326) reminded that ". . . As only a little research actually addresses the question of what is useful and what is perceived problematic from a user-perspective . . . evaluations are often focused on functionality rather than contextual issues." Hence, the argument here is in line with Kjeldskov and Graham (2003). The use of mobile devices in learning should go beyond the technical functionalities, and stress the contextual use of mobile devices. Kukulska-Hulme (2007) also suggested that the design should focus on planning-in good usability features rather than eliminating bad ones. The advanced features of mobile technologies include the situated and authentic access and interaction across different contexts of use (Jones & Issroff, 2007; Kukulska-Hulme, 2009). Mobile learning is recognized as contextualized learning, in which learners use mobile phones to interact not only with the digital content on its screen, but also with ambient objects, peers, and teachers for a immersive and authentic learning.

Hence, the design should follow Kjeldskov and Graham's (2003, p. 326) guideline in addressing "the question of what is useful and what is perceived problematic from a user-perspective" and Kukulska-Hulme's (2007, p. 6) suggestion of focusing on planning-in good usability features rather than eliminating bad ones. Indeed, tiny screen and limited input options are problematic to users when they access digital information. The design of mobile devices needs to focus on what is beneficial to learning because of such features. For example, Bradley, Haynes, and Boyle (2005) reported that the tiny screen size of PDA was viewed positively by students, who appreciated being able to have a quick look at the PDA while walking, just before an exam, rather than having to carry a book or A4 papers. In such circumstances, the tiny screen of PDA did not seem to be an issue.

Examples of the contextual use of mobile devices include the bird-watching system with which students can observe wild birds in nature using a wireless learning network to browse bird-related web information (Chen et al., 2003), and the museum nomadic browsing system with which students receive exhibit-related content via their mobile devices (His, 2003). Thereafter, the design concept of augmented reality has been proposed and widely employed by researchers to explore various types of synthesis of mobile digital content and real artifacts in different subject domains to provide students with an unprecedented way of

interactions and opportunity for reflections (Damala, Cubaud, Bationo, Houlier, & Marchal, 2008; Price & Rogers, 2004). Finally, as the advance of sensoring and positioning technologies, the context-aware systems (Cheverst, Mitchell, & Davies, 2002; El-Bishouty, Ogata, & Yano, 2007; Liu, Tan, & Chu, 2009; Naismith, Sharples, & Ting, 2005) are also valuable as they provide learners with context-related learning materials. These studies provided students with a positive experience of the overall learning activities. This study takes a further step to investigate whether the prior mentioned pitfalls of mobile devices would be of any nuisance to students in a contextualized mobile learning.

EVALUATION EXPERIMENT

The evaluation experiment probes into how learners perceive some frequently mentioned pitfalls of mobile devices in a proposed contextual use. In previous studies on the use of mobile devices in education, participating students complained about limited input and tiny display (Corlett et al., 2005; Liu, 2009; Thornton & Houser, 2005). Table 1 summarizes the questions asked in former research, which are also adopted for this study. The survey contains five questions. The responses are evaluated on the basis of a 5-point Likert scale with 1 indicating *strongly disagree* and 5, *strongly agree*.

Activity Design

This study explores the subject matter of learning English as a foreign language. Participating students are required to exercise their language skills and to carry out a language practice using mobile devices. Pre-scripted tasks for some specific contexts are designed, in which students need to rely on both the mobile devices and the contexts to finish the tasks. The task is designed as a problem-solving task.

Table 1. Perception of Mobile Device for English Learning

	Using mobile device to learn English	Pre-activity Mean (*SD*)	Post-activity Mean (*SD*)
1	The text is easy to read.	2.61 (0.92)	3.00 (1.53)
2	The video quality is clear.	2.83 (0.86)	3.67 (1.09)
3	The size of screen is appropriate.	2.56 (1.04)	3.11 (0.90)
4	Inputting text is easy.	3.00 (1.03)	3.56 (1.20)
5	The device is easy to operate.	2.94 (1.00)	3.44 (1.30)

The learners are told that a burglary has been committed in the Lin Family Mansion and Garden, where is a spot of historical interest in Taiwan. Since an international organization is here in Taiwan to help the police to find the burglary suspect, these agents communicate in English only. In the crime scene, the police have collected some evidence. The task for the students is to use this evidence to help the agents resolve the crime and find the suspect. There are six task assignments students need to accomplish. All evidence is designed according to the special context of different locations in the Garden. Related picture files and sound files are pre-saved in the mobile device. The tasks require the different operations of mobile devices and corresponding language skills. After completing all six assignments, students need to synthesize the results they get from each task and identify who the thief is.

For illustrating how the use of mobile device in this study is contextualized, the operation of mobile device in the first task is elaborated here. The task is to open the picture file in the mobile device and use MSN to inform headquarters of the three differences between the digital picture and the real portrait on the wall in the mansion (see Figure 1).

Under such design, the use of mobile device is contextualized. That is, the operation of mobile device needs to synthesize the authentic context material with the virtual information in the mobile device. The design may refer to the mixed-reality or augmented reality, which inspires this study to use mobile device and contextual objects around students to guide and foster students' communicative use of mobile devices. This study values the contextual experience of students' exercising their language skills to carry out a meaningful language practice.

Mobile Device

The mobile device used in this study is shown in Figure 2. It is of 120 × 70 × 20 mm with the screen size of 75 × 45 mm, 36 input keys, and 2.5 hours talk time.

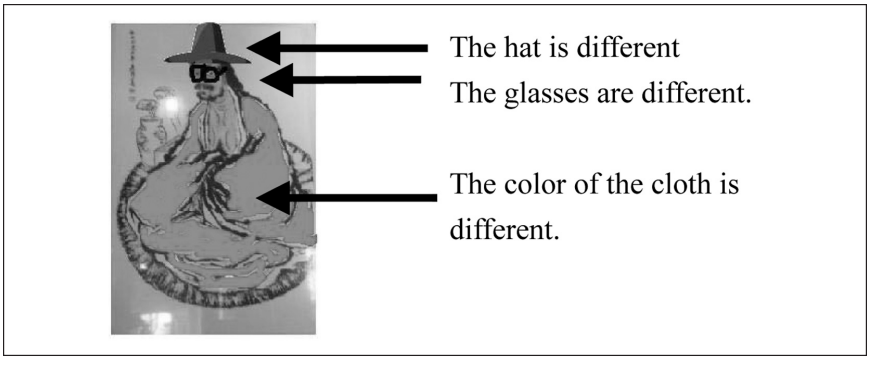

Figure 1. The portrait in the first task.

Figure 2. Mobile device used in this study.

Its functions include mobile MSN, MP3 player, and basic mobile phone functions of voice and SMS. These specifications are common in most mobile phones of modern day. This device is considered to carry the same pitfalls mentioned in literatures. The operation of the mobile device to perform the tasks in this study has been taught to students in the pre-task training. According to the observation of training, the operation is affordable for the learners.

Participants

A total of 35 sixth graders, 21 males and 14 females, participated in this study. In general, they started to have two 40-minute English classes from 3rd grade at school. All participants were randomly assigned into 11 teams consisting of three to four members each. These participants have had a computer course for learning how to use the computer in general. As to related experience in using technology tool for learning, 10 of these 35 students had used a computer to learn English. None of the participants had prior experience of learning English with mobile phones.

Under such specific context of study, using a mobile device to learn English is a novice experience for all the participants. This study explored how students would react to the usability of the mobile device. The pre-activity survey was conducted to assess the students' impression of using mobile devices to learn English during the pre-task training. Upon completion of the learning task, all participants had to complete a post-activity survey for evaluating whether there was any change in their perception of using mobile devices for English learning.

RESULTS

The collected data were analyzed and yielded a Cronbach Alpha coefficient of 0.803, which satisfies the requirement of survey reliability (Lim, Khine, Hew, Wong, Shanti, & Lim, 2003). Most learners had an unfavorable impression of using mobile devices in language learning. In the pre-activity survey, the average

response of each item is less than 3. After experiencing the contextualized MALL in this study, their responses to the same five items all exceeded 3. In other words, they had more positive perception of the usability of mobile devices after experiencing the contextualized MALL in this study. According to the paired samples test for significance, the perception toward video quality and ease of operation showed significant improvement at $p = 0.039$ and 0.035, respectively.

DISCUSSION

The results show that learners have more positive perception of the operation of the mobile device regarding the activity of English learning after experiencing the proposed contextualized mobile learning practice. In particular, students' perception of video quality and overall ease of operation of the mobile device improved significantly. Such change may partly be attributed to the specific device used in this study, this particular group of youngsters, and the subject domain investigated. Nevertheless, the results reveal that the pitfalls of a mobile device perceived by users in other studies can still be improved depending on how the mobile device is used. Waycott (2005) asserted that the factors affecting whether a device is easy or difficult to use depends greatly on the context in which it is used. This study provides a context in which a mobile device could be used. Similar to the prior finding in computer assisted language learning (Sagarra & Zapata, 2008), this study uses a contextualized mobile learning practice to shape students' attitudes toward learning with mobile devices.

The results obtained indicate that providing a contextualized mobile learning practice is a means to improving students' perception of the usability of mobile devices in learning. The contextual use of mobile devices is constructed upon the coherent design of the device, the digital information, ambient artifacts, users, and the subject domain as suggested in this study. One may refer to the concept of contextualizing the use of mobile devices in the framework of Ecology of Resources proposed by Luckin et al. (2005), which explores the ways in which mobile technology can be employed to link different contextual resource elements. This study argues that, with appropriate design, a link with contextual elements provided to users when they interact with the mobile device may facilitate users in their learning and alleviate common interface problems of mobile devices. The question left for educators now is how to adapt the resources they find within a particular context and design the context in a way that will enable students to interact effectively with mobile technology to meet their learning needs.

The features of mobile devices, which might be deemed as pitfalls, should be tailored in a specific context and pedagogical design of learning that help learners meet their learning needs, rather than treated as problematic to the learning. This study provides a different view of technology pitfalls when they are

addressed in learning. While prior studies have tackled the technology pitfalls with innovative designs, they focus on the pedagogies and technology implementation. For example, in the study of Luckin et al. (2005) on using mobile carbon monoxide (CO) sensing devices in a science inquiry, the tiny display of mobile device seemed to be a problem because it was visible only to the person holding it. On the other hand, the pedagogical design can have a shy student holding the mobile device that facilitates his/her interaction with other group members who have to rely on him/her in reporting the CO values.

Another example is IR technology, which is relatively restricted in terms of usage distance and direction, and cannot support the coordinated full-classroom action. Therefore, aggregation activities such as the classroom response system cannot be implemented with IR (Stuart, Brown, & Draper, 2004). However, infrared beaming can afford spatially directed, point-to-point communication. With this technology, students can point to the person they are beaming, and communicate only with their spatial neighbors at a time they choose.

The final example is the positioning system in a mixed reality game. The inaccuracies of global positioning systems (GPS) are exploited and manipulated by players in order to ambush and catch online players (Crabtree, Benford, Rodden, Greenhalgh, Flintham, Anastasi, et al., 2004). In such context, the inaccuracies became an exciting and special dynamics within the game, deepening the playing experience rather than being a source of breakdown that required constant repair from runners and players (Reeves, Pridmore, Crabtree, Green, Benford, & O'Malley, 2006). The problematic technology is re-appropriated for a specific instructional purpose which is pedagogically valuable. Researchers should not always rely on the traditional categorization of error and uncertainty as features of the system to be hidden and reduced, but also should consider accommodation and appropriation (Chalmers & Galani, 2004).

This study investigated the pitfalls of mobile devices from the users' point of view and focused on their attitude toward the use of mobile devices. Their attitude could be improved by their contextualized use of mobile devices. That is, the way to overcoming pitfalls of mobile devices is to provide students with a positive experience in using mobile devices for learning. This approach reflects a gradual change of the general usability research revealed by Kukulska-Hulme and Shield (2004), from a focus on "ease"—making systems easy to learn and easy to use—toward an interest in the user experience, which encompasses a wider set of concerns such as satisfaction, enjoyment, and helpfulness. This study provides a case study that justifies the key principles proposed by Kukulska-Hulme and Shield (2004) in the evolved approach to usability, enhancing and extending the way people work, communicate, and interact.

Finally, for a wide range of technologies, what teachers lack is an understanding of ways in which such technologies can be used critically and

creatively to support their teaching (Clark, Logan, Luckin, Mee, & Oliver, 2009). This study suggests the contextualized use of mobile devices to help students gain an innovative view of mobile devices and thereafter improve their perception of the usability of mobile devices. The proposed approach also answers the question raised by Christopher and Goolsbee (2010) of whether the trade-off between the use of a mobile device and the cognitive burden induced by the small screen is worthwhile. If the use of mobile devices lies only in personal flexibility, the answer is probably not. However, if the use of mobile devices is contextualized and brings an unprecedented learning experience to the user, the answer is definitely yes.

CONCLUSION AND FUTURE STUDIES

This study proposes an approach to overcoming the pitfalls of using mobile devices in learning, and the proposed approach has been evaluated in an experiment. The results obtained support our argument that the experience of contextualized use of mobile devices in learning will improve students' perceived usability of mobile devices.

This study also validates the proposal of using a specific context for evaluation. Plass (1998) suggested that, ". . . evaluation criteria for Human Computer Interaction need to be developed based on domain-specific learning processes and activities and on the cognitive processes that these activities involve." Similarly, more studies on different subject domains are needed to validate the proposed approach, and more cognition-oriented investigation is needed to provide a comprehensive picture of how to enhance the usability of mobile devices in learning.

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