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CULTURAL AND REGIONAL PERSPECTIVES

# Differences between mobile learning environmental preferences of high school teachers and students in Taiwan: a structural equation model analysis

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**Abstract** Mobile technology has been increasingly applied to educational settings in the past decade. Although researchers have attempted to investigate both students' and teachers' preferences regarding mobile learning, few studies have investigated the differences between the two, an understanding of which is important for developing effective mobile learning environments. To address this issue, a mobile learning environmental preference survey (MLEPS) consisting of eight factors, "ease of use," "continuity," "relevance," "adaptive content," "multiple sources," "timely guidance," "student negotiation" and "inquiry learning," was developed in this study. A total of 1239 students (609 males and 630 females) and 429 teachers (208 males and 221 females) who employed mobile technology to learn and teach in schools completed the questionnaire. From the structural equation models, it was found that the major difference between the preferences of teachers and students in learning with mobile technologies was that the teachers tended to focus more on the technical issues, while the students cared more about the richness and usefulness of the learning content. In addition, both the students and teachers considered that the "anytime" and "anywhere" support provided via the mobile technology played an important role during the learning activities, engaging them in searching for information, collecting data, interpreting data and summarizing findings. It is therefore suggested that learning environments which conform to both students' and teachers' preferences be developed in the future.

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**Keywords** Mobile learning · Environmental preferences · The perceptions of students and teachers · Secondary education · Teaching/learning strategies

## Introduction

Recent advances in computer and communication technologies have changed the way of teaching and learning (Bentsen et al. 2013). Many studies have reported the benefits of mobile and wireless network technologies that offered opportunities to engage students in interacting with real-world learning targets in the field via mobile devices (Kukulska-Hulme 2012). In the meantime, several governmental organizations have put a great deal of effort into implementing mobile technology-enhanced learning in school settings (Looi et al. 2014; Ozdamli and Uzunboylu 2014). For instance, in Taiwan, the Ministry of Education has provided a large number of resources to schools (e.g., assisting the schools in setting up wireless networks and mobile learning environments) as well as training programs to help teachers design mobile learning activities. Such a top-down promotion policy shows that the governments of those countries consider mobile learning as a potential learning approach in formal education.

Ruchter et al. (2010) further pointed out that the use of these emerging technologies makes learning quite different. In several courses, such as environmental education, it is important for students to make observations and collect data of natural phenomena in the field. In the traditional learning approach, without mobile and wireless technologies, students need to bring printed materials to the field (e.g., science parks) for observing and taking notes on the real-world learning targets. The effects of such an in-field learning approach might be limited since the students are not able to derive the required supplementary materials or interact with peers and teachers instantly (Ruchter et al. 2010; Schultz 2000). Via the help of these new technologies, however, students can now directly access the information they need and seek help from peers and teachers during field trips (Tan et al. 2012); in addition, their presence, actions and learning processes can be recorded, and the learning system can immediately detect their learning status so as to provide personal supports (Looi et al. 2014). Therefore, students today can be actively involved in their learning activities and access more adaptive learning content anywhere and anytime (Kamarainen et al. 2013).

On the other hand, scholars have indicated that nowadays teachers need to face the challenges of employing mobile technologies in school settings (Morrison et al. 2009; Vermunt 2007). The lack of professional development of mobile technology-enhanced learning designs for teachers is likely to result in boring curriculums, which might leave students lacking motivation in class (Beyers 2009). This phenomenon is frequently seen since mobile technology is new to most teachers (Webster and Son 2015). Therefore, in order to effectively apply mobile technology to school settings, educators and school managers need to understand the benefits and difficulties of conducting mobile learning activities in the existing curriculums. Moreover, to cater to students' learning preferences and to avoid pedagogical pitfalls, teachers need to understand the instructional needs in mobile learning contexts as well as students' preferences for mobile learning when developing learning activities (Vermunt 2007; Zhu 2013).

The purpose of this study was, therefore, to investigate both teachers' and students' perspectives and preferences in the context of mobile learning environments by examining and comparing the technical, content, and cognitive aspects.

## Literature review

### Students' and teachers' perspectives on learning

In the last three decades, researchers have proposed the importance of understanding students' or teachers' psycho-social characteristics in the classroom, since their perceptions and judgments regarding learning environments could mediate the instruction and interaction in their classrooms (Kearney et al. 2015). Table 1 shows a comparison of students' and teachers' perceptions of learning. For instance, in a classroom environment without technology, both students and teachers like the learning activities that fulfill individual learning opportunities, provide personalized guidance or interaction, and enable them to be active learners (De Hei et al. 2015; Patchen and Smithenry 2015). Fraser (1982) revealed some differences in the perceptions of students and teachers, that is, students' expectations of controlling their own learning pace was greater than the teachers' actual perceptions and expectations.

Owing to the improvement in technology, students and teachers have more opportunities to experience the benefits of technology-enhanced learning contexts (Bogdanovic et al. 2013; Chen and Huang 2012; Hwang et al. 2012). The exploration of students' and teachers' perceptions of technology in learning can aim to promote the congruence of classroom interactions and reduce the gap between learning and teaching (Vermunt and Verloop 1999). According to the previous research, it was found that students and teachers had positive attitudes toward information technologies (Christensen 2002). Nevertheless,

**Table 1** The comparison of students' and teachers' perceptions of learning

| Perception | Without technology | With technology | With mobile technology |
|---|---|---|---|
| Similarity | Prefer more individualized learning and interaction (De Hei et al. 2015; Fraser 1982; Patchen and Smithenry 2015) | Positive attitudes toward information technologies (Christensen 2002) | Look forward of applying mobile technologies in education (Ozdamli and Uzunboylu 2014) |
| Difference | | | |
| Student | Expected more individual learning opportunities (Fraser 1982) | Enthusiastic about technologies (Li, 2007)<br>Much more likely to use Facebook (Roblyer et al. 2010)<br>Expected more self-directed learning (Otter et al. 2013) | Utilized more applications of mobile learning management systems (Antonenko et al. 2013) |
| Teacher | Satisfied with actual individualized learning mode (Fraser 1982) | More negative attitude than students (Li 2007)<br>Prefer to use more "traditional" technologies, such as email (Roblyer et al., 2010)<br>Taking the important role in online courses (Otter et al. 2013) | Utilized few applications of mobile learning management systems (Antonenko et al. 2013)<br>Against using mobile phones in teaching and learning (Kafyulilo 2014)<br>Gainsaid mobile devices as a potential learning technology (Sad and Göktas 2014) |

some researchers still pointed out the differing student and teacher perceptions of information technology. Most students are more enthusiastic about technology than their teachers (Li 2007). Also, they tend to prefer more social interaction and self-directed learning, while teachers prefer to utilize the technologies they are proficient in, and are more likely to be the leader of online courses (Otter et al. 2013; Roblyer et al. 2010).

In the past decade, the advantages of mobile technology-enhanced learning have attracted the attention of researchers and school teachers (Chen 2013; Marty et al. 2013). Several studies have also employed survey methods to examine students' and teachers' perspectives on mobile learning (Gikas and Grant 2013; Sung et al. 2013). Ozdamli and Uzunboylu (2014) reported that both teachers and students look forward to applying mobile technologies in education; however, they identified some differences between students' and teachers' perceptions. For instance, students were able to utilize more applications of mobile learning systems than teachers (Antonenko et al. 2013), while teachers were opposed to using mobile phones in teaching and learning processes (Kafyulilo 2014), and gainsaid mobile devices as a potential learning technology (Sad and Göktas 2014).

From these studies, it was found that most students highly agreed with the advantages provided by technologies. On the contrary, some teachers possessed unfavorable attitudes or were unfamiliar with those technologies. In other words, the students and the teachers did not reach a consensus regarding the use of technologies in learning, and a gap between learning and teaching still existed.

## The advance and challenge of mobile technologies in learning

In recent years, the integration of mobile learning has transformed the learning model into student-centered learning (Chang et al. 2010; Saavedra and Opfer 2012). In this learning mode, mobile technologies have been regarded as a migrating process for students to transfer their learning knowledge and skills into the capabilities they need in the real world (Hwang 2014). Accordingly, several researchers have attempted to provide effective approaches to assisting learning by guiding students to learn in the real world and increasing teachers' confidence in developing mobile learning activities (Schuck et al. 2012). For instance, Hung et al. (2014) employed a video-based prompt approach in a context-aware mobile learning environment and found that the students' learning attitudes improved as a result, while Ekanayake and Wishart (2014) implemented a professional mobile-based development workshop and changed teachers' attitudes towards the use of mobile phones.

However, some empirical studies have pointed out the challenge of mobile learning, indicating that teachers' willingness is a crucial factor while developing and conducting mobile learning activities (Hargis et al. 2013; Ismail et al. 2013). Even though most teachers realize the potential value of such technologies in school settings (Webster and Son 2015), they seldom try to integrate mobile technologies into their classes due to the lack of professional training and technology supports in schools (Cochrane 2014; Chu 2014; Ozdamli and Uzunboylu 2014). For example, Kearney et al. (2015) and Herro et al. (2013) have found that teachers put low value on the aspect of mobile learning since the bandwidth of the wireless network in their schools was limited, and the assistance in developing learning content and pedagogical designs was not sufficient.

Despite those teacher perceptions of mobile learning, several governmental organizations have still put a great deal of effort into implementing mobile technology in regular courses (Looi et al. 2011; Ramos and Triñona 2010). In Taiwan, the Ministry of Education has provided a large amount of support to schools, assisting them in the development of their mobile learning environments, and training teachers to design their own mobile-based activities. However, mobile learning is often considered as "under-theorized in teacher education" (Baran 2014, p. 17). For school managers and educators, the implementation of mobile learning is a new challenge, and the learning environments today are different from those of the past (Ertmer and Ottenbreit-Leftwich 2013; Newhouse 2014). Thus, it is essential to investigate students' and teachers' needs related to mobile activities so as to develop well-constructed mobile-based environments (Ekanayake and Wishart 2014; Kafyulilo 2014; Sad and Göktas 2014). Among various learning perceptions, learning environmental preferences have been considered as one of the important elements correlated with the quality of teaching and learning (O'Bannon and Thomas 2014). These are related to individuals' epistemological beliefs and learning needs, which are significantly associated with their learning performance (Tsai 2008).

Therefore, the current study explores the mobile learning environmental preferences of both high school teachers and students. In order to understand the actual high school teachers' and students' needs in mobile learning activities, in this study participants were selected who had already experienced 1 year of mobile learning activities in their regular course. Therefore, the responses to this study could clearly reflect their needs when conducting mobile learning activities. Thus, their preferences regarding mobile learning can be more specific for developing well-constructed mobile-based environments. The validity and reliability of the mobile learning environmental preference survey were clarified, and the structural equation models were utilized to examine the differences in the preferences of the students and teachers. In summary, the research questions of this study are:

(1) Does the instrument designed to measure the high school teachers' and students' preferences in the mobile learning environments result in an interpretable factor structure, reflecting the intended constructs?
(2) What are the high school teachers' and students' preferences in mobile learning environments? And how did the teachers and students perceive their preferences in the mobile learning environments?
(3) What are the structural relationships of teachers' preferences in mobile learning environments?
(4) What are the structural relationships of students' preferences in mobile learning environments?
(5) According to the structural equation model (SEM) analyses, are there any differences between teachers' and students' mobile learning preferences?

## The framework of mobile learning preferences: technical, content, and cognitive

The definition of mobile learning has been clearly identified by Sharples et al. (2002). They indicated three factors as important elements when developing mobile learning environments, including the technology, content, and cognitive elements. The "technology" aspect of learning environments could be regarded as the fundamental factor which has high correlation with the "content" aspect. Moreover, the "technology" aspect and the "content" aspect could be the predictors of their "cognitive" aspect of learning strategies and outcomes (Hsu 2015; Lee and Kim 2015; Wen et al. 2004).

In particular, the technical concept of mobile learning environments refers to students' mobile technology adoption, their behaviors and intentions in learning (Vogel et al. 2014). Previous studies have investigated students' technology adoption and revealed that, through the user-friendly mobile devices, students can operate and then engage in learning efficiently (Kafyulilo 2014; Liaw et al. 2010). Moreover, students would like the learning system to automatically record their portfolios and enable them to engage in continuous learning (Chen 2013; Wong and Looi 2011).

On the other hand, the learning content has been regarded as an important element encouraging students to engage in active learning (Hwang et al. 2008). Due to the technology supports, the provision of abundant information and close-to-life learning sources should be focused on (Tsai et al. 2012). Moreover, adaptive and timely content, which has been recognized as a distinguishing feature in mobile learning, can engage students in learning and judging critically (Tsai et al. 2011; Wu et al. 2011).

Mobile technologies provide learning environments which align with the ideas about the practice of constructivism in education. The constructivist theory has generally asserted that knowledge is actively constructed by individuals, and that social interaction also plays an important role in the learning process (Akinoglu 2013; Donnelly 2010; Hwang et al. 2011; Marty et al. 2013). For instance, El-Bishouty et al. (2010) provided social networks in a mobile-based learning environment where college students could discuss and collaborate with their peers during the learning process. Tsai et al. (2012) provided a context-aware ubiquitous learning approach with personalized timely guidance and feedback to help students cope with problems encountered during the science inquiry process. Moreover, Kim et al. (2015) developed a mobile-based science inquiry activity to encourage students to collect solutions to problems and report scientific phenomena themselves.

Tsai et al. (2012) have further summarized a framework of mobile learning preferences, and verified that the characteristic of a mobile-based learning environment should include ease of use (EU), continuity (CO), relevance (RE), adaptive content (AC), multiple sources (MS), timely guidance (TG), student negotiation (SN), and inquiry learning (IL), as shown in Table 2.

**Table 2** The aspects and factors considered in the MLEPS

| Aspect | Factor | Description |
|---|---|---|
| Technical | Ease of use | Referring to the preference for ease of use of mobile devices. |
| | Continuity | Referring to the preference for the mobile learning environment to assist individuals in keeping continuously learning. |
| Content | Relevance | Referring to the individual's preference that the mobile learning environment represents real-life situations. |
| | Adaptive content | Referring to the preference that individuals can access information based on their requirements. |
| | Multiple sources | Referring to the preference that mobile learning environments consist of various relevant sources. |
| Cognitive | Timely guidance | Referring to the preference of individuals to receive support at the right time and in the right place. |
| | Student negotiation | Referring to individuals preferring to have opportunities to interact with peers in the mobile learning environment. |
| | Inquiry learning | Referring to individuals preferring to have opportunities to engage in inquiry in the mobile learning environment. |

In order to examine the difference in students' and teachers' mobile learning preferences, in this study the framework and questionnaire developed by previous researchers were adopted (Tsai et al. 2012). According to the theoretical review, these three aspects were suitable for explaining the students' and the teachers' learning environment preferences.

# Method

## Participants

In this study, a high school mobile learning program was conducted with the Ministry of Education in Taiwan, to counsel and help high school teachers implement mobile learning activities in regular courses. The participants, consisting of teachers and students from 38 high schools, incorporated mobile learning activities into their regular learning activities.

In order to avoid the mobile learning activities varying too greatly, this study referred to previous research (Chang et al. 2013; Lai and Hwang 2015; Shea and Bidjerano 2009) and the researchers consulted with experts experienced in mobile learning. Moreover, some training courses were held for the teachers to understand how to implement mobile learning activities in their regular courses, while regular consultations were also conducted via which the experts could give the teachers appropriate suggestions regarding the mobile learning activities they were attempting to implement, as shown in Fig. 1. As a result, the teachers of this study had the basic concept of integrating mobile technologies into their regular courses.

On the other hand, the mobile learning environment preferences survey was completed at the end of the academic year after the teachers and students implemented the planned


**Fig. 1** Training courses and consultations for teachers to develop their meaningful mobile learning activities

mobile learning activities. Therefore, the participants of this study had the basic concepts and experiences of mobile learning, and their responses were sufficiently reliable to describe the needs and opinions of the mobile learning environments. Finally, the participants responded to the survey on the Internet from September 2013 to May 2014, and totally, 1239 students (609 males and 630 females) and 429 teachers (208 males and 221 females) were enrolled in this study.

## Measurement

In order to investigate the teachers' and students' preferences in mobile learning environments, the mobile learning environmental preferences survey (MLEPS) was employed. This survey originated from a survey developed by Tsai et al. (2012). It was translated into a Chinese version and was examined by five experienced teachers to ensure that the high school students were able to understand the meaning of each item. Three aspects of mobile learning preferences have been defined: technical, content, and cognitive. The original questionnaire consisted of eight factors: EU, CO, RE, AC, MS, TG, SN, and IL. Each factor included 4 items, giving a total of 32 items in the questionnaire. Furthermore, the original survey was presented with a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). The total Cronbach's alpha value of the original survey was 0.97, and the original Cronbach's alpha values of the eight factors were 0.91, 0.89, 0.88, 0.88, 0.92, 0.87, 0.93, and 0.90, indicating that the reliability of the original questionnaire was good.

Continuing the investigation of students' mobile learning preferences (Tsai et al. 2012), this study expanded the research to explore high school teachers' mobile learning preferences, and to analyze the differences in the mobile learning environment preferences of high school teachers and students. As a result, 24 items (with each scale including 3 items) were included in the MLEPS, as shown in "Appendix 1". Furthermore, this questionnaire was also presented on a five-point Likert scale, whereby subjects with higher scores were likely to express stronger preferences for the specific features in mobile learning environments.

## Data analysis

This study involved four phases of the data analysis procedure, including exploratory factor analysis (EFA), confirmatory factor analysis (CFA), Welch's test in one-way heteroscedastic ANOVA, and structural equation modeling (SEM).

The EFA and CFA were adopted to confirm the validity and reliability of the teachers' and the students' MLEPS. The individual EFAs were conducted to clarify the structures of the teachers' and the students' mobile learning environment preferences, and half of the teachers' ($n = 215$) and half of the students' ($n = 619$) responses were randomly selected in the EFA analysis. In order to ensure the consistency and validity of the items in each group, those items with a factor loading of less than 0.5 and with many cross-loadings were omitted from the survey. Moreover, in order to ensure the consistency of items between groups for fair comparison, the two EFAs were synchronously analyzed. For instance, the item of MS4 was cross-loading in the teachers' structure in the current study, as the teachers considered that it was associated with more than one factor. For fair comparison, this item was omitted from both the teachers' and the students' structures. On the other hand, the responses of the other half of the teachers ($n = 214$) and students ($n = 620$) were used in the CFAs, which can specify the relations of the observed factors to their posited underlying constructs (Chau 1997).

In order to examine the difference in the teachers' and students' preferences in mobile learning environments, an initial examination was adopted by employing Welch's test in a one-way heteroscedastic ANOVA. Since the students and teachers are nested in this study, Welch's test is more reliable when the two samples have unequal variances and unequal sample sizes (Shieh and Jan 2015). On the basis of extensive empirical evidence of Type I error control and power performance, Welch's procedure is frequently recommended as the major alternative to the ANOVA *F* test under variance heterogeneity (Jan and Shieh 2014; Kang et al. 2015).

Finally, the SEMs were employed by using Linear Structure RELationships (LISREL), which can be used to confirm the validity of the scales in the questionnaires. Then, the teachers' and the students' structural relationships among the factors were evaluated via SEM, which offers a flexible and powerful means of examining the relationships among constructs (Kelloway 1998). On the other hand, the fit of the models was evaluated using various measures (Jöreskog and Sörbom 1993), such as $\chi^2$ per degree of freedom, the root mean squared error of approximation (RMSEA), the goodness of fit index (GFI), the normed fit index (NFI), and the comparative fit index (CFI).

## Results

### Validity and reliability of the teachers' and the students' MLEPS

To validate the survey of the teachers' and the students' MLEPS, two exploratory factor analyses with varimax rotated principal component analysis were performed to clarify both structures, as shown in "Appendix 2". The sample size in each group was big enough to explore the appropriate structure through EFA (Cattell 1978; Comrey 1973). On the other hand, all the variables in the overall KMO values were greater than 0.50 (Field 2000); the skewness values were less than 3, and the kurtosis values were less than 10 (Kline 1998). Moreover, the total variance explained was 83.64 and 82.26 %, respectively, and all of the communality levels were greater than 0.75. The results suggest that the factor analysis is favorable for explaining the teachers' and the students' MLEPS.

As a result, those participants' responses were grouped into the following factors: EU, CO, RE, AC, MS, TG, SN, and IL. All 24 items were retained in the final version of the teachers' and the students' preferences in mobile learning environments, and the ratios of sample size-to-variable were feasible (Cattell 1978; Onwuegbuzie et al. 2010). On the other hand, the Cronbach's alpha coefficients all showed high reliability, whether in each factor in each group or the overall values. Since the Cronbach's alpha value is too sensitive to the number of items, this study further employed the raw mean inter-item correlation as the examination of the internal consistency. The average raw mean inter-item correlations are 0.49 and 0.50, respectively. These values fall in the range of 0.15–0.50, representing good reliability in assessing the teachers' and students' preferences in mobile learning environments (Briggs and Cheek 1986; Clark and Watson 1995).

On the other hand, the CFAs further confirmed the construct validity and the structure of the students' and teachers' MLEPS, as shown in "Appendix 3". The fitness of the items for each scale of the teachers' mobile learning preferences ($\chi^2$ per degree of freedom = 1.64, RMSEA = 0.05, GFI = 0.88, NFI = 0.97, CFI = 0.99) and the fitness of the items for each scale of the students' mobile learning preferences ($\chi^2$ per degree of freedom = 2.09, RMSEA = 0.02, GFI = 0.94, NFI = 0.96, CFI = 0.98) indicated sufficient fits and also confirmed the structures.

## The difference in teachers' and students' preferences in mobile learning environments

This study further compared students' and teachers' different preferences in mobile learning environments. The teachers' (n = 215) and students' (n = 619) responses selected in the EFA analysis were further analyzed using Welch's test in the one-way heteroscedastic ANOVA.

The results of Welch's test indicate that the eight factors, EU, CO, RE, AC, MS, TG, SN, and IL, differed significantly between the two groups, as shown in Table 3. Furthermore, the standardized mean-difference effect size (Cohen's *d*) is designed for contrasting two groups on a continuous dependent variable. It can be computed from means and standard deviations. The results of the effect size (*Cohen's d*) indicate a large effect size (Cohen 1988). That is, compared with students, teachers tended to show stronger preferences in mobile learning environments. According to this result, it is necessary to understand whether differences exist in the teachers' and the students' mobile learning environmental preference in the structural relationships.

## The structural equation modeling of the teachers' and the students' MLEPS

Since the proposed structural relationships between variables can be conducted through LISREL analysis (Kelloway 1998), all participants' responses on the CFA version surveys were subjected to SEM analysis (the teachers' n = 214 and the students' n = 620). Each of the fits were evaluated and compared with the various measures shown in Table 4. The results of the fit measures of the teachers' MLEPS model ($\chi^2$ per degree of freedom = 2.31, RMSEA = 0.08, GFI = 0.83, NFI = 0.96, and CFI = 0.98) and the results of the students' MLEPS model ($\chi^2$ per degree of freedom = 3.61, RMSEA = 0.06, GFI = 0.90, NFI = 0.98, CFI = 0.90) indicated highly satisfactory fits and confirmed the models' structures of preferences in mobile learning environments. Since the GFI (0.83) of the teachers was approaching the recommended value (0.9), researchers (e.g., Browne and Cudeck 1993) suggest that this would be an acceptable model fit.

In the structural model of the teachers' preferences in mobile learning environments, the summary of the maximum-likelihood parameter estimates and significance of the *t*-values

**Table 3** The scores of the factors of mobile learning preferences for teachers and students

| | EU | CO | RE | AC | MS | TG | SN | IL |
|---|---|---|---|---|---|---|---|---|
| Teacher (n = 215) | 3.91 (0.81) | 4.04 (0.63) | 4.01 (0.66) | 4.25 (0.64) | 4.22 (0.59) | 4.16 (0.60) | 4.26 (0.60) | 4.22 (0.59) |
| Student (n = 619) | 3.15 (0.94) | 3.52 (0.76) | 3.51 (0.74) | 3.69 (0.80) | 3.65 (0.74) | 3.50 (0.74) | 3.66 (0.78) | 3.70 (0.74) |
| Welch | 127.14*** | 96.87*** | 84.21*** | 105.34*** | 128.38*** | 172.34*** | 133.16*** | 108.16*** |
| Cohen's *d* | 0.87 | 0.76 | 0.71 | 0.77 | 0.85 | 0.98 | 0.86 | 0.78 |

*** $p < .001$

**Table 4** Fit measures for the structural model of teachers' and students' MLEPS

| Fit index | Teachers | Students | Recommended value |
|---|---|---|---|
| $\chi^2$ | 533.37 | 833.72 | – |
| Degree of freedom | 231 | 231 | – |
| $\chi^2$ per degree of freedom | 2.31 | 3.61 | <5 |
| RMSEA | 0.08 | 0.06 | ≦0.08 |
| GFI | 0.83 | 0.90 | ≧0.90 |
| NFI | 0.96 | 0.98 | ≧0.90 |
| CFI | 0.98 | 0.99 | ≧0.90 |

Teachers, teachers' structural model of mobile learning environments preferences; Students, students' structural model of mobile learning environments preferences

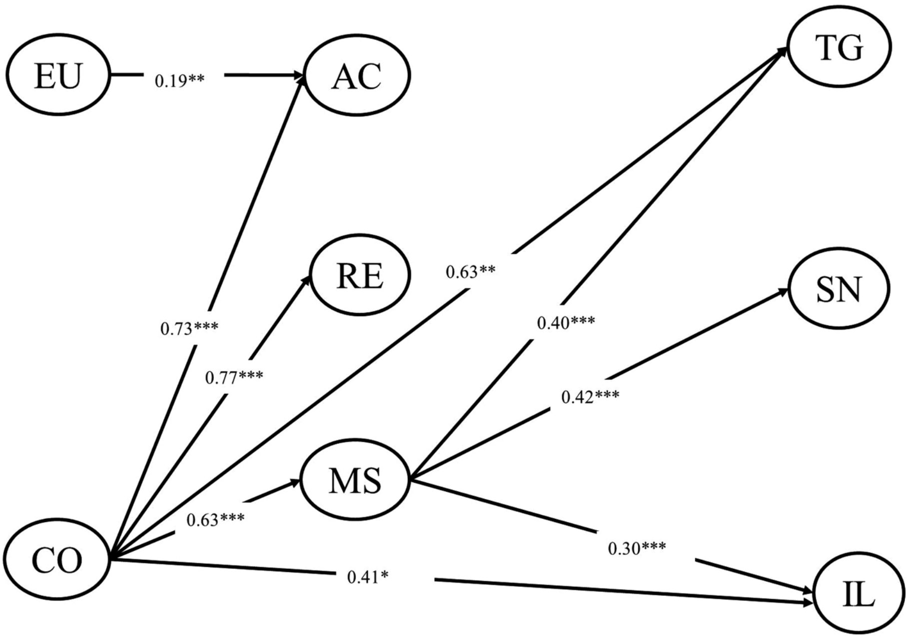


**Fig. 2** Structural model of the relationships to teachers' mobile learning environment preferences (*EU* ease of use, *CO* continuity, *AC* adaptive content, *RE* relevance, *MS* multiple sources, *TG* timely guidance, *SN* student negotiation, *IL* inquiry learning)

are presented in Fig. 2. The statistically significant relationships are shown with solid lines, and, for a cleaner display, other non-significant relationships are concealed. Furthermore, the level of significance of the *t*-value grows gradually from 2.58 ($p < 0.01$) to 3.29 ($p < 0.001$) (Jöreskog and Sörbom 1993).

In terms of the technical aspect, EU had a relationship with AC, indicating that a friendly interface in mobile learning plays an important role in assisting teachers to access the information they need for teaching. On the other hand, CO had a strong relationship to all of the factors in the content aspect of the teachers' preferences, including AC, RE and

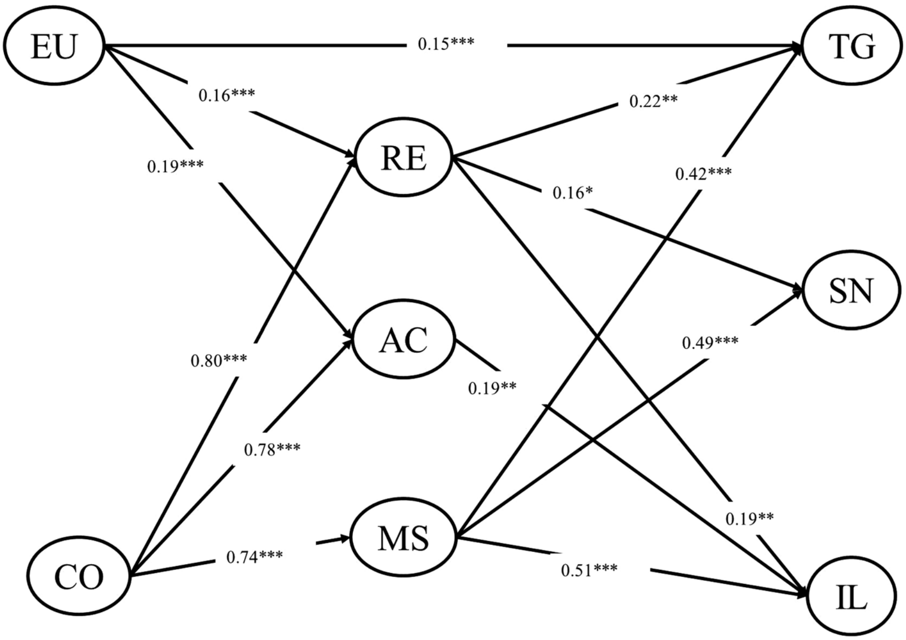


**Fig. 3** Structural model of the relationships to students' mobile learning environment preferences (Significant *t*-value, $p < 0.001$. *EU* ease of use, *CO* continuity, *AC* adaptive content, *RE* relevance, *MS* multiple sources, *TG* timely guidance, *SN* student negotiation, *IL* inquiry learning)

MS. This indicates that in order to provide multiple, true-to-life and realistic information in mobile learning environments, good wireless technologies keeping track of learners should be included. Moreover, CO was the significant predictor explaining TG and IL in the cognitive aspect, indicating that a continuous learning procedure is an important factor for TG and IL, in the teachers' views.

In addition, from the aspect of content, MS was the mediator explaining the variation in TG, SN and IL. This result indicates that the provision of MS in mobile learning environments plays an important role when the teachers develop more cognitive activities in mobile learning environments.

On the other hand, the students' structural model was shown in Fig. 3. In the technical aspect of the students' preferences in mobile learning environments, EU is related to RE, AC and TG, indicating that a friendly interface in mobile learning is essential when acquiring relevant and adaptive learning resources. Moreover, a friendly interface is an important characteristic when accessing TG in mobile learning activities. On the other hand, CO was a positive predictor of RE, AC and MS. That is, wireless technology plays an important role in students' learning activities for acquiring relevant, adaptive and multiple learning resources.

In the content aspect of the students' preferences, RE and MS were considered as important positive mediators to TG, SN and IL. That is, multiple and relevant sources for learning could engage students in cognitive learning processes. In addition, AC was a positive predictor of IL, indicating that learning content responding to students' needs can foster the students' inquiries during their learning.

**Table 5** The significant predictors of the teachers' and the students' MLEPS

| | RE | AC | MS | TG | SN | IL |
|---|---|---|---|---|---|---|
| EU | $S^+$ | $T^+$ $S^+$ | | $S^+$ | | |
| CO | $T^+$ $S^+$ | $T^+$ $S^+$ | $T^+$ $S^+$ | $T^+$ | | $T^+$ |
| RE | | | | $S^+$ | $S^+$ | $S^+$ |
| AC | | | | | | $S^+$ |
| MS | | | | $T^+$ $S^+$ | $T^+$ $S^+$ | $T^+$ $S^+$ |

$T^+$ teacher positively predict, $S^+$ student positively predict, *EU* ease of use, *CO* continuity, *AC* adaptive content, *RE* relevance, *MS* multiple sources, *TG* timely guidance, *SN* student negotiation, *IL* inquiry learning

Moreover, this study compared the teachers' and the students' significant relationships in the SEM structural analysis, as shown in Table 5. The variables in the columns are the predictors of the factors in the rows; for instance, the factor of EU positively predicts AC in both the teachers' and the students' preferences. According to this table, the teachers and the students reached consensus that CO in the technical aspect could predict their content preferences, and MS in the content aspect is important during their cognitive learning. It could be considered that when developing well-designed mobile learning environments, the provision of good wireless services and multiple learning sources are the fundamental elements. In addition, the teachers and the students both agreed that a friendly interface can support them in acquiring adaptive learning content, since their preferences for EU positively predicted AC.

On the contrary, there are some differences in the teachers' and students' preferences. In the teachers' view, the CO factor can predict the cognitive process during mobile learning activities, such as TG and IL. That is, when conducting ubiquitous learning, the seamless and continuous wireless connection plays an important role in providing TG and supporting IL. However, the students in this study did not consider CO to be as important as the teachers did in their cognitive learning process.

In the views of the students, their preferences for EU are highly related to RE and TG. Moreover, the more relevant learning content they receive (RE), the more cognitive learning processes they experience in their mobile learning activities (TG, SN, students negotiation; and IL, inquiry). Finally, the students considered that adaptive learning content is necessary, as AC predicted IL. In sum, the students in this study considered that the learning content they received during their learning plays an important role in their cognitive learning processes. However, the teachers, who had the responsibility for designing the learning activities, did not consider EU, RE, or AC as essential factors in developing cognitive learning activities.

## Discussion and conclusions

In recent years, mobile learning has been regarded as an imperative learning approach, and several governments, especially that of Taiwan, have started to be concerned about the implementation of mobile learning in their formal education (Chang et al. 2010). However, the development of mobile learning environments or activities have challenged teachers, because this learning approach is different from those of the past (Ertmer and Ottenbreit-

Leftwich 2013). Therefore, it is essential to realize teachers' and students' needs regarding mobile learning to develop well-constructed mobile-based environments and activities.

In this study, a survey design research was employed to investigate the preference for mobile learning of Taiwan high school teachers and students. To understand their specific preferences, the participants of this study had to experience 1 year of mobile learning activities in their regular school courses. Therefore, those participants could reflect their actual thoughts and perceptions of mobile learning.

According to the structural model of the Taiwan high school teachers' mobile learning environment preferences, it was found that continuity (CO) may be regarded as an important factor in mobile learning environments. This result indicates that learning records, given good wireless technology, can assist teachers in adding more authentic, true-to-life, and varied learning resources to their activities (El-Bishouty et al. 2010; Wu et al. 2011). On the other hand, with respect to the Taiwan high school students' preferences, the aspect of content (relevance, adaptive content, and multiple sources) has been regarded as an important bridge between the technical and cognition aspects of their learning. For instance, the students felt that having continuous learning may engage them in acquiring more relevant resources, more information based on their requirements, and multiple data during their searching activities (Tsai et al. 2011; Vogel et al. 2014). Furthermore, the adaptive information they acquire during their learning activities may engage them in more cognitive learning processes (Hsu 2015).

In comparison to the structures of Taiwan high school teachers' and students' preferences in mobile learning environments, there were some agreements regarding what both teachers and students considered to be important. The most important factor is continuously learning based on wireless communication, which provides efficient information acquisition. The other is the quality of multiple sources of information which can satisfy the teaching and learning needs. Therefore, for future development of mobile learning environments, the critical aspects of the continuity of the wireless services and the multiple sources provided for learning should be focused on (Kearney et al. 2015; Wong and Looi 2011).

Nonetheless, the Taiwan high school teachers and students also differed in some of their preferences. The teachers focused more on the technical effects of continuous learning when developing mobile learning activities (Kordaki 2013), while the students cared more about the effectiveness of the adaptive and useful learning content for their cognitive learning process (Kollöffel 2012). These results imply a need to develop awareness of the gap between teachers' and students' preferences in mobile learning, especially in the technical and content aspects (Kitsantas and Chow 2007). If teachers develop the mobile learning activities without taking students' preferences into account, the improper learning design could seriously affect students' learning performance.

Compared to previous research related to students' perceptions of learning, this study found that the Taiwan high school students considered that the value of the content they acquired is an essential element of their cognitive learning. On the other hand, previous studies have indicated that teachers possessed relatively unfavorable attitudes toward technologies, and applied fewer mobile technologies in learning; however, the independent *t* test in the study showed that the teachers held stronger preferences than the students. The reason for this outcome may be the professional training in mobile technologies, which may have improved the teachers' attitudes toward mobile learning (Ekanayake and Wishart 2014). Moreover, the teachers' SEM result indicated that the technical effects of continuous learning were important in terms of improving teachers' willingness to use mobile phones in teaching and learning.

Consequently, this study examined the differences in the mobile learning preferences of the Taiwan high school teachers and students, and found that the teachers might prefer to have a well-constructed wireless and technological environment, while the high school students may prefer to acquire information more efficiently to help with their learning. It is suggested that when teachers develop their mobile learning activities, not only the provision of technology and wireless support should be considered, but also the learning content accommodating students' needs should be taken into account. Furthermore, the feature of continuous wireless support and the provision of multiple sources could be important factors to consider when developing a mobile learning environment suitable for both teachers' teaching and students' learning. Therefore, the current study concludes with two suggestions for educators in Taiwan or in other countries with similar government policies:

(1) Support for teachers to conduct mobile learning: sufficient technical support (e.g., wireless, mobile devices, learning record systems) should be provided to help increase teachers' intentions to integrate mobile learning activities into their regular courses (Hung et al. 2013).
(2) Training courses for helping teachers develop mobile learning activities: teachers are encouraged to notice specific learning approaches that could benefit students in their classes using mobile technology.
(3) Assistance for students in mobile learning: in order to engage students in experiencing more cognitive learning procedures in mobile learning environments, educators should consider more carefully the quality and RE of the learning content (Looi et al. 2011).

This study faced some limitations. It explored the differences in the mobile learning preferences only focusing on high school teachers and students in Taiwan. It cannot, therefore, be generalized to all students' and teachers' thoughts about learning in all circumstances. Moreover, the over-redundancy of the survey might lead to high Cronbach's alpha values, which could cause controversy. In order to make the survey more reasonable, it is suggested that future studies explore individuals' perceptions of mobile learning using other research methods, such as in-depth interviews or observation methods. In future work, it is also suggested that studies investigate the learning environment preferences for different learning strategies, such as collaborative learning and project-based learning. Moreover, it is recommended that learning environments conform to both teachers' and students' preferences be developed.

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## Appendix

### Appendix 1

See Table 6.

**Table 6** The MLEPS questionnaire items

| Item | |
|---|---|
| Factor 1: ease of use (EU) | |
| EU1 | When navigating mobile learning, I prefer that it has good wireless communication. |
| EU2 | When navigating mobile learning, I prefer that it takes only a short time to learn how to operate mobile devices. |
| EU3 | When navigating mobile learning, I prefer that it has user-friendly mobile devices. |
| Factor 2: continuity (CO) | |
| CO1 | When navigating mobile learning, I prefer that it can provide the functions of recording what I have learned. |
| CO2 | When navigating mobile learning, I prefer that it can provide the tools to continue with my learning. |
| CO3 | When navigating mobile learning, I prefer that it can record the learning path that I have already been on. |
| Factor 3: relevance (RE) | |
| RE1 | When navigating mobile learning, I prefer that it presents information that is relevant to me. |
| RE2 | When navigating mobile learning, I prefer that it contains meaningful information for learning. |
| RE3 | When navigating mobile learning, I prefer that it presents realistic tasks. |
| Factor 4: adaptive content (AC) | |
| AC1 | When navigating mobile learning, I prefer that it can provide information which I need, e.g. documents, images, voice, etc. |
| AC2 | When navigating mobile learning, I prefer that it can provide a correct way to learn what I should know. |
| AC3 | When navigating mobile learning, I prefer that it can provide information in which I am interested. |
| Factor 5: multiple sources (MS) | |
| MS1 | When navigating mobile learning, I prefer that it can discuss a learning topic through various perspectives. |
| MS2 | When navigating mobile learning, I prefer that it can present a learning topic using different methods. |
| MS3 | When navigating mobile learning, I prefer that it can offer various information sources to explore a learning topic. |
| Factor 6: timely guidance (TG) | |
| TG1 | When navigating mobile learning, I prefer that it can provide useful feedback to guide learning at the right time and in the right place. |
| TG2 | When navigating mobile learning, I prefer that it can provide meaningful questions to promote thinking at the right time and in the right place. |
| TG3 | When navigating mobile learning, I prefer that it can provide experts' guidance to facilitate advanced learning. |
| Factor 7: student negotiation (SN) | |
| SN1 | When navigating mobile learning, I prefer that I can get the chance to talk to other students. |
| SN2 | When navigating mobile learning, I prefer that other students can discuss their ideas with me. |
| SN3 | When navigating mobile learning, I prefer that I can ask other students to explain their ideas. |
| Factor 8: inquiry learning (IL) | |
| IL1 | When navigating mobile learning, I prefer that I can carry out investigations to test my own ideas. |
| IL2 | When navigating mobile learning, I prefer that I can conduct follow-up investigations to answer my new questions. |
| IL3 | When navigating mobile learning, I prefer that I can design my own ways of investigating problems. |

## Appendix 2

See Table 7.

**Table 7** The EFA results of the teachers' and the students' MLEPS

| | Teachers (N = 215) | | | | Students (N = 619) | | | |
|---|---|---|---|---|---|---|---|---|
| | EFA factor loading | Mean | SD | Cronbach's alpha | EFA factor loading | Mean | SD | Cronbach's alpha |
| Factor 1: ease of use (EU) | | | | | | | | |
| EU1 | 0.84 | 3.91 | 0.81 | 0.88 | 0.80 | 3.15 | 0.94 | 0.85 |
| EU2 | 0.86 | | | | 0.84 | | | |
| EU3 | 0.82 | | | | 0.75 | | | |
| Factor 2: continuity (CO) | | | | | | | | |
| CO1 | 0.72 | 4.04 | 0.63 | 0.87 | 0.71 | 3.52 | 0.76 | 0.90 |
| CO2 | 0.74 | | | | 0.76 | | | |
| CO3 | 0.76 | | | | 0.75 | | | |
| Factor 3: relevance (RE) | | | | | | | | |
| RE1 | 0.81 | 4.01 | 0.66 | 0.87 | 0.66 | 3.51 | 0.74 | 0.86 |
| RE2 | 0.80 | | | | 0.75 | | | |
| RE3 | 0.74 | | | | 0.70 | | | |
| Factor 4: adaptive content (AC) | | | | | | | | |
| AC1 | 0.72 | 4.25 | 0.64 | 0.88 | 0.72 | 3.69 | 0.80 | 0.87 |
| AC2 | 0.73 | | | | 0.66 | | | |
| AC3 | 0.74 | | | | 0.68 | | | |
| Factor 5: multiple sources (MS) | | | | | | | | |
| MS1 | 0.69 | 4.22 | 0.59 | 0.90 | 0.78 | 3.65 | 0.74 | 0.91 |
| MS2 | 0.77 | | | | 0.79 | | | |
| MS3 | 0.79 | | | | 0.73 | | | |
| Factor 6: timely guidance (TG) | | | | | | | | |
| TG1 | 0.64 | 4.16 | 0.60 | 0.89 | 0.75 | 3.50 | 0.74 | 0.89 |
| TG2 | 0.66 | | | | 0.73 | | | |
| TG3 | 0.60 | | | | 0.71 | | | |
| Factor 7: student negotiation (SN) | | | | | | | | |
| SN1 | 0.77 | 4.26 | 0.60 | 0.92 | 0.77 | 3.66 | 0.78 | 0.90 |
| SN2 | 0.80 | | | | 0.84 | | | |
| SN3 | 0.77 | | | | 0.79 | | | |
| Factor 8: inquiry learning (IL) | | | | | | | | |
| IL1 | 0.84 | 4.22 | 0.59 | 0.94 | 0.76 | 3.70 | 0.74 | 0.91 |
| IL2 | 0.83 | | | | 0.78 | | | |
| IL3 | 0.76 | | | | 0.77 | | | |
| Overall alpha | 0.96 | | | | 0.96 | | | |
| total variance explained | 83.64 % | | | | 82.26 % | | | |

**Table 7** continued

| | Teachers (N = 215) | | | | Students (N = 619) | | | |
|---|---|---|---|---|---|---|---|---|
| | EFA factor loading | Mean | SD | Cronbach's alpha | EFA factor loading | Mean | SD | Cronbach's alpha |
| KMO statistics | 0.94 | | | | 0.95 | | | |
| Skewness value for each item | −1.17 to −0.50 | | | | −0.48 to −0.10 | | | |
| Kurtosis value for each item | −0.18 to 5.43 | | | | −0.73 to 0.48 | | | |

## Appendix 3

See Table 8.

**Table 8** The CFA result for the teachers' and the students' MLEPS

| | Teachers (N = 215) | | Students (N = 620) | |
|---|---|---|---|---|
| | CFA factor loadings | *t*-values | CFA factor loadings | *t*-values |
| Factor 1: Ease of use (EU) | | | | |
| EU1 | 0.84 | 14.48*** | 0.82 | 23.08*** |
| EU2 | 0.91 | 16.32*** | 0.79 | 21.82*** |
| EU3 | 0.82 | 13.97*** | 0.78 | 21.73*** |
| Factor 2: Continuity (CO) | | | | |
| CO1 | 0.72 | 11.73*** | 0.85 | 25.46*** |
| CO2 | 0.88 | 15.51*** | 0.88 | 27.07*** |
| CO3 | 0.83 | 14.30*** | 0.83 | 24.63*** |
| Factor 3: Relevance (RE) | | | | |
| RE1 | 0.76 | 12.27*** | 0.81 | 23.75*** |
| RE2 | 0.83 | 14.08*** | 0.87 | 26.50*** |
| RE3 | 0.81 | 13.56*** | 0.87 | 26.74*** |
| Factor 4: Adaptive content (AC) | | | | |
| AC1 | 0.86 | 15.15*** | 0.82 | 23.88*** |
| AC2 | 0.82 | 14.14*** | 0.85 | 25.36*** |
| AC3 | 0.76 | 12.54*** | 0.85 | 25.26*** |
| Factor 5: Multiple sources (MS) | | | | |
| MS1 | 0.83 | 14.55*** | 0.84 | 24.94*** |
| MS2 | 0.91 | 17.04*** | 0.88 | 27.08*** |
| MS3 | 0.92 | 17.19*** | 0.86 | 25.93*** |
| Factor 6: Timely guidance (TG) | | | | |
| TG1 | 0.87 | 15.71*** | 0.85 | 25.30*** |
| TG2 | 0.90 | 16.56*** | 0.90 | 27.75*** |
| TG3 | 0.78 | 13.34*** | 0.80 | 23.11*** |

**Table 8** continued

| | Teachers (N = 215) | | Students (N = 620) | |
|---|---|---|---|---|
| | CFA factor loadings | *t*-values | CFA factor loadings | *t*-values |
| Factor 7: Student negotiation (SN) | | | | |
| SN1 | 0.81 | 14.14*** | 0.87 | 26.76*** |
| SN2 | 0.92 | 17.13*** | 0.91 | 28.71*** |
| SN3 | 0.93 | 17.67*** | 0.88 | 27.02*** |
| Factor 7: Inquiry learning (IL) | | | | |
| IL1 | 0.92 | 17.45*** | 0.89 | 27.62*** |
| IL2 | 0.94 | 18.23*** | 0.90 | 28.15*** |
| IL3 | 0.88 | 16.09*** | 0.83 | 24.69*** |

*** $p < 0.001$

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