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Study on Student Engagement in the Course Chemistry Pedagogy Based on Mobile Learning

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ABSTRACT

The pre-service teachers admitted in 2012, 2013 and 2014 to the teacher education program in College of Chemistry in Central China Normal University who have adopted mobile learning in the course Chemistry Pedagogy were selected as the research objects, and those admitted in 2014 but have not had any experience of mobile learning in the course Chemistry Pedagogy were selected as the control group. Through questionnaires, interviews and classroom observations, student engagement in the course was studied. It was found that the pre-service teachers supported the use of mobile devices in their class and their engagement in the course Chemistry Pedagogy based on mobile learning was acceptable; their behavioral engagement, cognitive engagement and emotional engagement were mutually highly positively correlated, but their behavioral engagement was significantly higher than cognitive engagement and emotional engagement; mobile learning significantly promoted students' course engagement; while to adopt mobile learning technology efficiently, it is necessary to design teaching carefully, trying to stimulate students' cognitive initiative and self-control in learning to guarantee their deep cognitive engagement; overcoming the emotional barriers generated by technical exchanges and stimulating long-lasting and stable learning motivation can better promote their emotional engagement in chemistry teacher education programs.

1. Research background

With the development of mobile computing technology, mobile learning has become an important learning mode, which can provide learners with new learning opportunities, make teaching and learning methods more interesting, help students realize the collaborative learning, knowledge creation, efficient information search and improve the interaction and communication between teachers and students as well as the relationship between students.

Mobile learning refers to the acquiring of knowledge through contexts, rather than just the accumulating of knowledge through mobile technology. It involves five factors: learners, teachers, contents, environments and assessment. It is also believed that mobile learning has seven characteristics: ubiquitous, portable size of mobile tools, blended, private, interactive, collaborative, and instant information (Ozdamli & Cavus，2011). Some schools have tried to combine the 5E model（Engagement, Exploration, Explanation, Elaboration, and Evaluation）with mobile learning in the real teaching contexts. The teaching results show that mobile learning can improve students' class engagement to a certain extent (Looi, Sun, Seow & Chia, 2014). According to the National Survey of Student Engagement (NSSE), there is a mutual positive correlation between students' achievement, satisfaction and engagement. Other similar studies concerning mobile learning and online learning have also found that engagement positively affects the academic performance of students (Ronel, 2018; Looi, Sun, Kim & Wen, 2018). However, there are few studies on the impact of mobile learning technology on students' engagement in teacher education programs.

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Teachers' inadequate preparation for the integration of mobile technology and curriculum teaching has always been an important factor in affecting the use of mobile devices in a formal learning environment (Sung, Chang & Liu, 2016; Ronel, 2018).Teachers' readiness and attitudes towards mobile learning significantly influence their acceptance of mobile learning modes (Tezer & Beyoğlu, 2018).Teachers' perceptions of the usefulness and convenience of integrating mobile technology in the curriculum, as well as their own digital literacy, anxiety and self-efficacy in teaching are key factors in influencing their willingness to adopt mobile teaching modes(Mac, Jeffrey & Kinshuk, 2014). Therefore, it is necessary to provide training and guidance to pre-service and in-service teachers to help them be more confident in the application of mobile devices into teaching (Tess, 2013). In order to improve the quality of educational courses for pre-service teachers, this study integrated mobile learning technology into the course Chemistry Pedagogy, attempting to help pre-service teachers effectively master related professional theories and teaching practices and make their application of mobile technology into their future teaching activities with more ease and skills.

"Chemistry Pedagogy" is a course which pre-service chemistry teachers in teacher education programs in teachers' colleges are to study. In this course they learn chemistry teaching theories and practices and master some important teaching skills in chemistry, which will lay a good foundation for these pre-service teachers in carrying out chemistry teaching and research in the future. This course plays an important role in the teacher education of pre-service chemistry teachers and their future professional development. In the process of cultivating innovative talents, the key is to have innovative teachers. In teacher education programs, the traditional teaching mode in which teachers' teaching and guidance are in the center has become inadequate and cannot meet the professional development needs of pre-service teachers. Can the integration of mobile learning technology into teaching provide an opportunity for the present teaching which is in the dilemma? Is it possible to improve the engagement of pre-service teachers in their course study? With these questions, our study attempted to find out whether the use of mobile learning technology in the course Chemistry Pedagogy can have a positive impact on the engagement of pre-service chemistry teachers.

2. Literature review

The previous empirical research on mobile learning focuses on the development of mobile learning tools, the effectiveness of mobile learning and the influencing factors. The mostly researched field is applied sciences such as linguistics, followed by humanities, formal sciences, social sciences and natural sciences. In the field of education, mobile learning is mostly researched qualitatively or quantitatively, and there is a lack of mixed method research.

In the process of developing mobile learning tools, scholars have constructed mobile learning theories, creating or promoting new teaching methods, models, theories or mobile learning frameworks to explore how to use new tools or technologies in learning (Lim, Fadzil & Mansor, 2011; Wu, 2015; Gikas & Grant, 2013; Churchill & Wang, 2014; Engin & Donanci, 2015). As to the assessment of mobile learning, it is mainly the assessment of the effectiveness of mobile learning platforms, learners' attitudes towards mobile learning and their tendencies to use mobile devices for learning (Viberg & Grönlund, 2013; Song, Wong & Looi, 2012). It is found that learners' learning motivations, beliefs, attitudes, perceptions and values, as well as their age, gender, ability, experience, learning styles and culture all have certain influence on the effectiveness of mobile learning.

2.1 Mobile learning in teacher education

he traditional training modes cannot meet the professional development needs of teachers, and the rise of mobile learning has undoubtedly solved the problem of how to balance the teaching and learning of teachers. The conveniency, mobility and ubiquitous communication of mobile devices enable learners to learn with mobile devices without the limit of time and place, providing teachers with more choices in learning methods and prepare them well for more challenges in the future.

When it comes to mobile learning, the topics of teacher training and support for teachers have been the least researched ones (Pedro, Barbosa & Santos, 2018; Ekanayake & Wishart, 2014; Wu, Wu, Chen, Kao, Lin & Huang, 2012). Based on the analysis of some mobile learning projects carried out in Europe, Kukulska-Hulme, Sharples, Milrad, Arnedillo-Sánchez and Vavoula (2009) found that no matter at the European continent level or national level, teacher development or training programs seem rarely to involve mobile learning. As a result, teachers are confronted with challenges both theoretically and practically in integrating mobile technology into teaching (Pedro, Barbosa& Santos, 2018; Baran, 2014; Schuck, Aubusson, Kearney& Burden, 2013; Kearney & Maher, 2013). At present, the research topics on mobile learning in teacher education mainly center on teachers' attitudes and perceptions as well as the effects and challenges in the process of applying mobile devices for the promotion of learning in teacher education programs.

The commonly used mobile learning methods in teacher education programs include teacher workshops (Ekanayake & Wishart, 2014), PLC(Professional Learning Community) (Schuck, Aubusson, Kearney & Burden, 2013) and literacy counseling practices (Bates & Martin, 2013). In this process, the role of educators has changed from the content provider to a facilitator (Husbye & Elsener, 2013), who can integrate into COP(Computer Oriented Programs) or PLC to help learners engage in the professional dialogue in mobile learning, such as sharing stories of their own previous teaching practices, participating in the creation of collaborative resources, helping learners enter the mentor or peer support systems etc. (Herro, Kiger & Owens, 2013). Valtonen, Havu-Nuutinen, Dillon and Vesisenaho (2011) allowed learners to access and share handouts by using social software in mobile devices in a teacher education program. Järvelä, Näykki, Laru and Luokkanen (2007) turned to mobile interactive tools to enhance learners' engagement in the lectures. Schuck, Aubusson, Kearney and Burden (2013) organized pre-service teachers to vote through text messages or "quick response" option.

Pre-service teachers can also be the organizers of mobile learning contents (Husbye & Elsener, 2013), such as creating digital narratives by capturing and editing videos and sharing them at mobile film festivals (Schuck, Aubusson, Kearney & Burden, 2013), and using mobile equipment to organize work and have access to reference tools such as dictionaries or periodic table of elements (Franklin, Sexton, Lu & Ma, 2007). Pre-service teachers can easily connect with their mentors, some teacher educators or other pre-service teachers with their mobile devices such as smart phones (Cushing, 2011), PDA (McCaughtry & Dillon, 2008) and Weibo (Schuck, Aubusson, Kearney & Burden, 2013) to share feedback (Foulger, Burke, Williams, Waker, Hansen & Slykhuis, 2013), receive virtual training (Seppälä & Alamäki, 2003), and submit school observation forms and weekly electronic journals (Crippen & Brooks, 2000; Shotsberger, 2003). It is also applicable for the tutors to integrate the technology into the designing of curriculum (Foulger, Burke, Williams, Waker, Hansen & Slykhuis, 2013) and provide real-time guidance (Kommers, 2009).

The previous research generally considers mobile learning as a useful way to extend the learning experience of teachers and improve their skills in integrating mobile technology into teaching (Looi, Sun, Seow & Chia, 2014). In order to promote the mobile teaching practice of pre-service teachers, Ronel (2018) designed a collaborative and explorative mobile teaching program driven by the core theme, including four stages "exploring", "learning", "adapting" and "applying". Mobile learning technology provides personalized learning experience for pre-service teachers (Herro, Kiger & Owens, 2013), such as helping pre-service teachers get resources in time (Shotsberger, 2003), allowing for their engagement in knowledge creation, reflection and sharing of teaching practices (Aubusson, Schuck & Burden, 2009), helping them understand and develop new literacy skills (Husbye & Elsener, 2013), providing them with opportunities to explore mathematics in reality(Kearney & Maher, 2013) and conduct scientific surveys, engage in a rich language learning environment and explore the actual physical education (McCaughtry & Dillon, 2008). Mobile learning technology can enhance the social interaction of pre-service teachers (Järvelä, Näykki, Laru &Luokkanen,2007; Valtonen, Havu-Nuutinen, Dillon & Vesisenaho, 2011), promote collaborative construction of knowledge (Järvelä, Näykki, Laru & Luokkanen, 2007), provide more efficient and personalized assessment techniques (Nikou & Economides, 2018; Chen, 2010), improve the mobility of pre-service teachers (Husbye & Elsener, 2013), fundamentally change the organization of classroom in teacher education programs and associate pre-service teachers with larger communities (Cushing, 2011; Husbye & Elsener, 2013; Kearney & Maher, 2013).

Mobile learning also poses challenges for teacher education programs, such as potential ethical issues (cyberbullying, privacy, security in terms of filing, classroom experience sharing and other electronic materials, etc.) (Aubusson, Schuck & Burden, 2009), ongoing requirement for technical and material support, accessibility of mobile devices, lack of expertise in integrating mobile technology (Foulger, Burke, Williams, Waker, Hansen & Slykhuis, 2013), unreasonable use of mobile devices, etc. Therefore, in the process of mobile learning in teacher education programs, it is necessary to guide pre-service teachers to use mobile learning devices reasonably, and select an effective and appropriate method to evaluate the effects of mobile learning, only through which the professional development of teachers could be truly promoted

2.2 Student engagement in mobile learning

Student engagement is one of the important predictors of learning quality (Burch, Gerald Heller, Nathan, Burch, Freed, Rusty, Steed & Steve, 2015). According to the report on the US "2006 High School Survey of Student Engagement (HSSSE) ", student engagement refers to the relationship between students and the following elements: adults, peers, rules, schedules, courses and teaching in schools (Yazzie, 2007). Student engagement is reflected in the process of coordination between students' behavior and teachers' teaching behavior. It is a process of students' supporting, influencing and creating teaching activities with full enthusiasm, characterized by proactive responses, design, construction, performance, collaboration and development. Studies have shown that highly motivated students demonstrate a high degree of classroom engagement (Schunk, 2008), and students who highly engage in class are more enthusiastic about their learning and can effectively improve the quality of their learning (Eryılmaz, 2014)

In the HSSSE, student engagement was researched from three dimensions: cognitive (intellectual, academic) engagement, behavioral (social) engagement and emotional engagement. On the basis of this research frame, Wang (2017) constructed a three-dimensional four-level model of student engagement, trying to analyze the quality of student engagement from four levels: frequency, breadth, depth and experience.

The primary influencing factor of student engagement is the teaching, followed by learning environments, and then parents' support (Yazzie, 2007; Virtanen, 2015). Students' self-efficacy, gender and previous academic achievement also have some influence (Yazzie, 2007). Therefore, it is advisable to start to develop a harmonious teacher-student relationship, organize fair and balanced classroom discussion activities for students, pay attention to the questions and feedback from them, promote their thinking and metacognition, encourage their communication and expression, develop their creative ability and design scientific and rational evaluation criteria to stimulate the participating enthusiasm of students. Mobile learning has the advantages of ubiquity, portable size of mobile tools, blending, privacy, interactivity, collaboration, and instant information, providing a possible solution for the improvement of classroom engagement. Research has begun to explore the use of mobile learning method for the improvement of student classroom engagement. Rogers and Price (2008) found that mobile tools used for the collaborative inquiry activities can promote students to engage more in discussion, interpretation, sharing and reflection.

Although most studies have shown that mobile learning has had positive effects on learning(Wu, Wu, Chen, Kao, Lin & Huang, 2012; Chee, Yahaya, Ibrahim & Noor Hassan, 2017), there are still studies showing that mobile devices can cause learners to distract from their learning (Shirky, 2014; Sana, Weston & Cepeda, 2013). Excessive use of social media can increase learners' cognitive load, affect their cognitive-emotional preoccupation, and reduce their cognitive behavioral control in the use of social networking sites (SNSs), which will ultimately affect their academic achievement (Cao, Masood, Luqman & Ali, 2018). College students claim that social networking applications that are not used in teaching can potentially interfere with their concentration in the classroom, while more mature learners believe that this is not the case, and whether students' engagement is influenced mainly by learners' personalities or mobile devices has not yet been identified(Gikas & Grant, 2013). Lepp, Barkley and Karpinski (2015) emphasize the need to carefully consider the use of mobile devices in teaching, and to carefully identify the relationship between the use of social media and academic achievement. Learners who use social networking platforms to learn are eager to seek the same, which may be potentially harmful to some important learning strategies including critical inquiry, confrontation, disagreement and dissent and harmful to the core of collaborative study-educational dialogue (Friesen & Lowe, 2011) and jeopardize deep thinking of learners. The core of human endeavor to share and collaborate is themselves, not machines or media (Jenkins, Ito & Boyd, 2016), so it is more critical to build a meaningful participatory culture in the classroom of adopting mobile learning.

But the design theory of mobile learning has not been fully elaborated (Pedro, Barbosa & Santos, 2018), most research just on creating a mobile learning environment, and the learning experience offered being short-term and practice-oriented rather than being essential. Few studies have integrated mobile technology into a systematic curriculum design for sustainable and scalable learning. Few researchers have conducted a tracking study of behavioral changes of teachers and students brought out by long-term mobile learning. Therefore, Looi, Sun, Kim and Wen (2018) developed a science course based on mobile technology to solve the above problems, attempting to explore student engagement and identify potential influencing factors in mobile learning through long-term data collection and learning process tracking.

3. Research questions and assumptions

This study aimed to explore the engagement of pre-service chemistry teachers in the course Chemistry Pedagogy based on mobile learning, analyze the relevance and difference of behavioral engagement, cognitive engagement and emotional engagement, and explore the influence of mobile learning on the engagement of pre-service chemistry teachers in the course.

Student engagement was divided into three main dimensions: behavioral (social) engagement, cognitive (intellectual, academic) engagement and emotional engagement.

Behavioral engagement emphasizes the engagement of students in social activities and academic activities such as downloading learning documents, participating in discussions, answering questions, and doing homework in and out of the classroom. It can be evaluated based on detailed learning behavior data.

Cognitive engagement describes students' efforts, commitments and learning strategies in learning, that is, the work students do and the way they do their work. This dimension is mainly focused on the engagement of students in teaching activities in the classroom, and can be regarded as "mind engagement". It can be evaluated with specific indicators such as thinking about relevant learning resources, reflection on homework, and comparison of their own opinions with those of teachers and peers.

Emotional engagement emphasizes the sense of contact or alienation between students and the curriculum teaching, that is, students' status in the course, the way the course works, and the feelings of students in learning the course. These feelings are more in the inner world of students, not always manifested as observable actions and behaviors, and can be regarded as "inner engagement". It can be evaluated with such indicators as the sense of pleasure and satisfaction of learning.

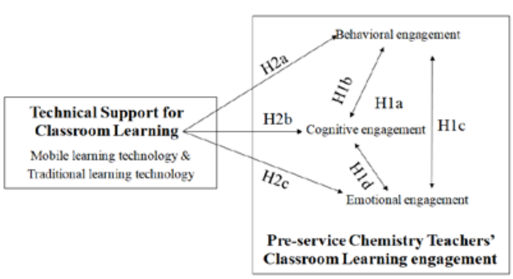

Fig. 1. Research analysis framework

This study proposed seven research hypotheses:

H1a: In the course Chemistry Pedagogy based on mobile learning, the degrees of pre-service teachers' behavioral engagement, cognitive engagement and emotional engagement are the same.

H1b: In the course Chemistry Pedagogy based on mobile learning, the behavioral engagement of pre-service teachers is positively correlated with their cognitive engagement.

H1c: In the course Chemistry Pedagogy based on mobile learning, the behavioral engagement of pre-service teachers is positively correlated with their emotional engagement.

H1d: In the course Chemistry Pedagogy based on mobile learning, the cognitive engagement of pre-service teachers is positively correlated with their emotional engagement.

H2a: In the course Chemistry Pedagogy based on mobile learning, the behavioral engagement of pre-service teachers is higher than that of the traditional course Chemistry Pedagogy.

H2b: In the course Chemistry Pedagogy based on mobile learning, the cognitive engagement of pre-service teachers is higher than that of the traditional course Chemistry Pedagogy.

H2c: In the course Chemistry Pedagogy based on mobile learning, the emotional engagement of pre-service teachers is higher than that of the traditional course Chemistry Pedagogy.

4. Research methods

4.1 Technical design of the course Chemistry Pedagogy based on mobile learning

The classroom of the course Chemistry Pedagogy based on mobile learning of teacher M has been chosen as our research classroom. In the classroom, students bring their own mobile devices such as smart phones, tablets, laptops and other smart terminals into the classroom to begin their learning.The course teaching consists of three parts: a learning resource system, an interactive evaluation system and an information releasing system, which have been constructed based on the Cloud classroom of the university , social media (the QQ group), Kahoot!, Questionnaire network, Teachermate and other network platforms.

Table 1 Technical design of the course Chemistry Pedagogy based on mobile learning

Network platforms	Learning resource system	Interactive evaluation system	Information releasing system
Cloud classroom	Syllabus Teaching plan Teaching calendar Courseware Learning resources	Homework Test Discussion Classroom survey Evaluation from students Supervisory feedback	Notice
Social media (the QQ group)	Group files Web page push Hyperlink	Group asking Group voting	Group message Group announcement
Kahoot!		Fast responding	
Questionnaire network		Online survey and test	
Teachermate		Sign-in, online discussion, quiz, fast response, randomly asking	

The Cloud classroom platform of Central China Normal University is based on Cloud computing and big data. Based on modern education theories, taking the curriculum teaching, learning and management as the core elements and combining the classrooms on campus with the Cloud virtual classrooms, this platform aims to establish effective connection of the spaces of university, department, management, teaching faculty, students and courses, which serves teachers and students of the whole university. Through the Cloud classroom platform, teachers can have a good management of their teaching of the curriculum, teaching contents, homework releasing and correcting, practice activities, personalized guidance, teaching analysis, providing students with the guidance of practical teaching and online learning which includes online synchronized course learning, MOOC-based extended learning, submission of assignments, community communication, learning feedback, personalized learning analysis and so on.

Social media (the QQ group) is a social interaction software that provides real-time information interaction for teachers and students. Based on the function of the QQ group and the characteristics of classroom teaching activities, teachers and students can use the QQ group to send and receive group news, make and receive group announcements, carry out group voting, have group questioning, make web page pushing, link, share resources and so on. For example, they can make full use of the QQ group to have real-time speeches and discussions and carry out group voting to determine the quality of teachers' teaching and students' presentations; teachers can use the QQ group to deliver important announcements, and present questions which every student in class can answer at the same time, and all the answers are displayed in the QQ group, which can be read by both teachers and students. Teaching resources in the QQ group are shared at any time which increases the generation and flexibility of teaching.

Kahoot! is a game-based evaluation platform of learning. It is mainly composed of multiple-choice questions, having a music background and countdown answering function, which can fully arouse the learning enthusiasm of learners. Questionnaire network is an online survey and test platform, and the problem types on this platform are diversified, which can help researchers and teachers better understand and diagnose learners' learning state. Teachermate is a classroom interactive application tool based on the WeChat platform, which provides various interactive functions such as classroom sign-in, test and discussion. All the three platforms can provide researchers and teachers with timely statistics and feedback concerning test results, and an intuitive "S-P" curve chart, which will provide intuitive, visual data support for the monitoring, diagnosing and adjusting of the teaching process. The three platforms can be well used to analyze the learning situation of learners in the initial stage of teaching, make a formative evaluation of the teaching in the middle stage and conduct a summative evaluation of the teaching in the final stage.

For the sake of designing teaching well, in the classroom different mobile learning technologies and techniques can be integrated reasonably and fully to build a mobile learning community, in which diverse mobile learning activities are organized and classroom engagement of students can be improved。

4.2 Research objects

The research objects are 147 pre-service teachers admitted in 2012, 2013 and 2014 (49 each year) to College of Chemistry in Central China Normal University who all have finished learning the course Chemistry Pedagogy based on mobile learning taught by teacher M (Class A), and another 49 admitted in 2014 and taught by teacher N but have not had mobile learning in the course Chemistry Pedagogy were selected as the control class(Class B). The differences in teachers' teaching styles, teaching contents, teaching methods etc. were eliminated by the way of collective lesson preparation.

4.3 Research tools

According to the characteristics of mobile learning, the specific situation of Chemistry Pedagogy classroom and the US NSSE survey, we formed our research framework from the following three dimensions: behavioral engagement, cognitive engagement and emotional engagement and designed classroom observation scales, questionnaires and interview outlines for the investigation of the engagement of pre-service chemistry teachers in the course Chemistry Pedagogy based on mobile learning.

Using classroom observation scales, we carried out classroom observations for one academic year, observing the class activities and recording the number of students involved in raising and answering questions, presenting what they have learned and other classroom activities. Meanwhile, the downloading times of electronic learning materials in the QQ group platform were recorded.

The questionnaire was designed according to the Likert 5-point scale for the investigation of students' recognition of the role of mobile learning technology in enhancing students' engagement in class.The total number of questions in the questionnaire is 24. A total of 147 questionnaires were distributed and 129 valid questionnaires were obtained, with an effective feedback rate of 87.8%.

According to classroom observations and the questionnaires, 16 participants with higher engagement, 16 with intermediate engagement and 16 with lower engagement were selected respectively for face-to-face interviews. Based on the interview outline designed previously, each interviewee was interviewed for 8-10 minutes. Interview outcomes were recorded on the spot and analyzed later.

The software SPSS 23.0 was used for data entry and statistic analysis, which mainly involved descriptive statistics, correlation analysis and one-way variance analysis.

4.4 Reliability and validity of research tools

129 questionnaires were coded, and then values were assigned, from 1 to 5, standing for "quite disapprove" to "quite agree" respectively. Exploratory factor analysis (PRIN CIPAL component, VARIMAX rotation) was carried out for the determination of the most meaningful engagement structure. Considering the inflection point of the Scree plot and the content analysis of the project cluster (factor load of each item), a three-factor solution was adopted to create a reliable structure validity involving behavioral engagement, cognitive engagement and emotional engagement. The total variance explained by the three factors was 64.71%, indicating that the questionnaire had good structural validity. The statistical results were analyzed for consistency. The overall reliability of the questionnaire was 0.931, indicating that the questionnaire had good reliability. The measurement tools used in this study and the factor loading for each item have been detailed in the appendix.

Table. 2. Summary of questionnaire reliability and validity

		Dimensions		
	Overall	Behavioral engagement	Cognitive engagement	Emotional engagement
Number of questions	24	8	8	8
Alpha reliability	0.931	0.812	0.849	0.901
Project differentiation	0.388—0.736			
Cumulative variance contribution rate	64.71%			

5. Research results

5.1 Pre-service chemistry teachers' attitudes towards mobile learning

By classroom observations, we found the number of students participating in classroom activities exceeded 98.0%, the number of students who answered their teacher exceeded 95.9%, the number of students who downloaded the QQ files reached 92.4%, and the number of students who engaged in raising questions reached 61.6%.The survey results show that 76.8% of pre-service chemistry teachers learned the course Chemistry Pedagogy for 2 hours or more within a week after class on mobile devices.

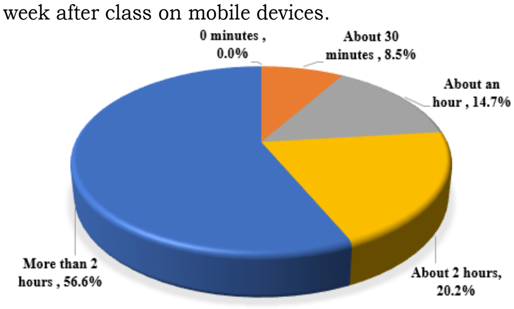

Fig. 2. Duration of pre-service chemistry teachers learning Chemistry Pedagogy through mobile devices within a week

The vast majority (accounting for 97.67%) of pre-service chemistry teachers were supportive of the use of mobile devices in chemistry class. Most of them believed that mobile learning was very convenient and efficient. Through mobile devices, they could freely search for problems and answers and easily have access to abundant teaching resources. Everyone can engage in teaching activities, which meets individual needs without being bound by time and place.

S1: Through mobile devices I can learn by myself anytime and anywhere, making full use of piecemeal time. When confronted with confusing problems, I can turn to the tutors for help through the social media, or search for the answers by myself on the mobile devices, which is really convenient, fast and practical.

The reasons offered by pre-service chemistry teachers for not supporting the use of mobile learning are that mobile learning tended to distract the attention of those learners with poor self-discipline who can chat with others, browse the news on the Internet or play games while learning through mobile devices.

S2: My self-control is poor. I can't help but browse the web or chat with my friends.

5.2 Class engagement in the course Chemistry Pedagogy based on mobile learning

Statistical analysis of the data acquired through the questionnaires (see Table 3) revealed that the overall average engagement of the pre-service chemistry teachers in the course Chemistry Pedagogy based on mobile learning was 3.66 (5-point scale), which was acceptable. As can be seen from Table 4, the pre-service teachers had significant differences in the three engagement dimensions (F(2,384)=22.135, p<0.001). After comparison, behavioral engagement (M=3.97) was significantly higher than cognitive engagement (M=3.57) and emotional engagement (M=3.49, and the assumption H1a could not be supported.

Table. 3. Statistics of pre-service chemistry teachers' engagement in the course Chemistry Pedagogy based on mobile learning (n=129)

Student engagement	Mean	SD
Behavioral engagement	3.97	0.616
Cognitive engagement	3.57	0.578
Emotional engagement	3.49	0.683
Overall	3.66	0.544

Table. 4. Single-factor variance analysis and comparison summary of pre-service chemistry teachers' engagement in three dimensions

Variation source	SS	df	MS	F	Post-comparison
Between groups	17.404	2	8.702	22.135***（p<0.001）	Behavioral engagement > Cognitive engagement
In groups	150.965	384	0.393		Behavioral engagement > Emotional engagement
Total	168.369	386			

The decision coefficients between behavioral engagement and cognitive engagement, behavioral engagement and emotional engagement, cognitive engagement and emotional engagement were 0.663, 0.583 and 0.649, respectively, and all reached extremely significant levels, indicating there was a very significant positive correlation mutually between pre-service teachers' behavioral engagement, cognitive engagement and emotional engagement. According to the decision coefficients, the three dimensions were mutually highly positively correlated, supporting the previous research hypotheses H1b, H1c and H1d.

Table. 5. The correlation test between three dimensions of pre-service teachers' engagement in the course Chemistry Pedagogy based on mobile learning

	1	2	3	4
1.Behavioral engagement	1			
2.Cognitive engagement	.663**（H1b+）	1		
3.Emotional engagement	.583**（H1c+）	.649**（H1d+）	1	
4.Overall	.844**	.881**	.878**	1

–a: Original scale was Yes/No, therefore these items could not be included in Cronbach's alpha values but only correlations computed after manipulation on the scale were converted to a continuous scale.
***p < 0.001. **p < 0.01. *p < 0.05.

5.3 Impact of mobile learning on the engagement of pre-service chemistry teachers

The data of the questionnaires of Class A (with mobile learning) and Class B (without mobile learning) showed that the engagement of students in Class A (M=3.87) was slightly higher than that of Class B students (M=3.74). And the internal difference of Class A (SD=0.480) was smaller than that of Class B (SD=0.586) (see Table 6).Taking the class as an independent variable, and the engagement of students as a dependent variable, we conducted the sample t test. Table 6 shows that the variance was homogeneous by t test, with t=1.138, p=0.258>0.05, indicating that there was no significant differences between the engagement of Class A students and Class B students

Table 6 Comparison of differences in engagement of Class A and Class B

Dimension	Class A (n=48)		Class B (n=48)		t-test for Equality of Means	
	Mean	SD	Mean	SD	t	Sig (two-tailed)
Behavioral engagement	4.20	0.560	3.84	0.604	2.991**	0.004
Cognitive engagement	3.68	0.549	3.63	0.628	0.454	0.651
Emotional engagement	3.72	0.576	3.75	0.673	-0.292	0.771
Overall	3.87	0.480	3.74	0.586	1.138	0.258

The behavioral engagement of Class A based on mobile learning was significantly higher than that of Class B. Pre-service chemistry teachers actively engaged in raising questions, answering questions, and discussing in Class A. In classroom observations, we found that almost all of them engaged in the teaching activities organized through the mobile way. Compared with those who did not use mobile devices for learning, their enthusiasm for engagement had been significantly improved, and the interest in learning had been stronger. In mobile learning, the Internet is used as a platform and its educational resources are abundant and diverse. Mobile learning platforms provided rich learning materials for pre-service chemistry teachers and broadened their horizons, but pre-service teachers could not see and think deeply. At the beginning of mobile learning, their interest and engagement was high. With the deepening of teaching and the increasing frequency of using mobile devices for learning, their interest and enthusiasm showed a downward trend.

5.3.1 Impact of mobile learning on behavioral engagement of pre-service chemistry teachers

The majority of the 129 learners in the course Chemistry Pedagogy based on mobile learning made full use of the information releasing system and learning resource system. For example, 74.5% of them actively downloaded and viewed the QQ group learning files, and 76.7% often paid attention to the QQ group dynamics. Most pre-service teachers actively used interactive platform systems to conduct interactive learning. For example, 62.1% actively engaged in the QQ group discussions, 60.5% actively answered the questions in the QQ group, 73.7% checked others' answers in the QQ group, 76.0% completed their Cloud platform homework through mobile devices with high quality, and 82.1% checked the homework feedback from their teachers in time.

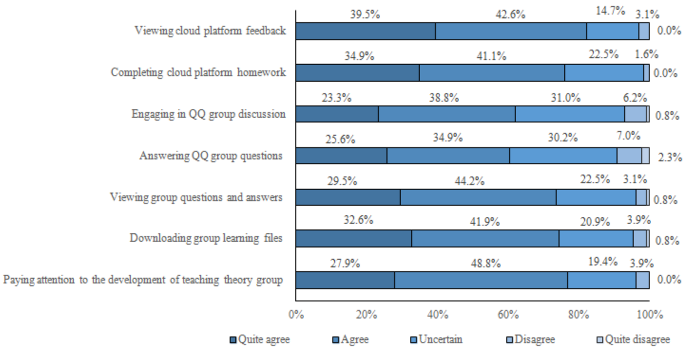

Fig. 3. Statistics of behavioral engagement in the course Chemistry Pedagogy based on mobile learning

The survey results based on the questionnaires of Class A and Class B showed that the behavioral engagement of Class A(M=4.20) was higher than that of Class B (M=3.84), and the internal difference of Class A (SD=0.560) was smaller than that of Class B (SD=0.604) (see Table 6).Taking the class as an independent variable, and the behavior engagement of students as a dependent variable, the sample t test was conducted. Table 6 shows that the variance was homogeneous by t test, with t=2.991, p=0.004<0.01, indicating that the behavioral engagement of Class A was significantly higher than Class B. The assumption of H2a was proved valid.

In the course Chemistry Pedagogy, the teacher guided and supervised the pre-service chemistry teachers to engage in the teaching. Therefore, based on classroom observations, we found that almost everyone engaged and the teaching effect was very satisfying. Among 49 pre-service chemistry teachers in Class A, more than 95.9% used mobile devices for Q&A, 98.0% were engaged in classroom activities, and 92.4% downloaded the QQ files. In contrast, in the questionnaire survey of 129 pre-service chemistry teachers, it was 60.5%, 62.1% and 74.5%, respectively in these three categories, all of which were far lower than that obtained through classroom observations, indicating that the pre-service chemistry teachers were not really involved in mobile learning. Their engagement was not deep, indicating the need of teachers to provide them with guidance and supervision.

Time investment is an important indicator of behavioral engagement. 76.8% of pre-service chemistry teachers spent 2 hours or more each week after class in learning the course Chemistry Pedagogy on mobile devices. Mobile learning has been subtly integrated into their lives. Learners enjoy its mobility and efficiency and continue to learn chemistry knowledge anytime and anywhere after class.

82.1% of the research objects checked the teacher's homework feedback in time through the mobile devices, which is the highest approval proportion of the behavior engagement dimension, and the highest support proportion in the entire questionnaire. In the interview, the pre-service chemistry teachers expressed their expectations that the teacher can correct their online homework in time and give back timely feedback, pointing out their specific strengths and weaknesses. The mobile learning interaction system can provide good support for teaching students in accordance with their aptitude in teacher education programs and enhancing the behavioral engagement of pre-service teachers.

S3: After submitting my homework, I hope that the teacher will correct it in time and give me back timely feedback. I want to have the specific suggestions from the teacher concerning my strengths and weaknesses.

S4: When the homework is submitted on the Cloud platform, the teacher can be instantly informed and offer immediate feedback to the student. Every time after I submit my homework, I am looking forward to the feedback from the teacher. The shortcomings and existing problems revealed through my homework can help me improve a lot if they are pointed out and corrected in time by the teacher, and the immediate feedback can be realized in mobile learning.

5.3.2 Impact of mobile learning on cognitive engagement of pre-service chemistry teachers

The majority of the 129 learners in the course Chemistry Pedagogy based on mobile learning could reflect on the online resources provided by mobile devices. For example, 63.6% of the respondents actively reflected on the webpage push in the QQ group, 62.8% thought deeply in combination with the learning materials, 62.0% deepened their understanding of the problems by consulting the QQ group, 56.6% reflected on their assignment, and 55.1% of the respondents thought independently before turning to the answers offered by the teacher.

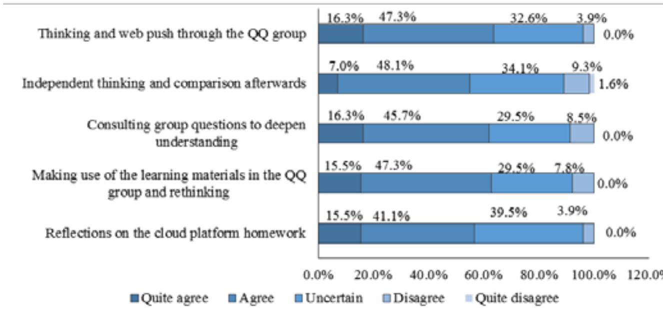

Fig. 4. Statistics of cognitive engagement in the Course of Chemistry Pedagogy based on mobile learning

The survey results based on the questionnaires of Class A and Class B showed that the cognitive engagement of Class A (M=3.68) was higher than that of Class B (M= 3.63), and the internal difference of Class A (SD=0.549) was smaller than that of Class B (SD=0.628) (see Table 6). Taking the class as an independent variable, and the students' cognitive engagement as a dependent variable, we conducted the sample t test. Table 6 shows that the variance was homogeneous by t test, with t=0.454, p=0.651>0.05, indicating that there was no significant difference between Class A and Class B in cognitive engagement. The previous assumption of H2b was proved invalid.

Mobile learning resources are so abundant that pre-service chemistry teachers have long been accustomed to superficial reading. They just glanced through the QQ learning files uploaded, the webpage push etc,. which just expanded their capacity of thinking, but there was a lack of deep thinking. In mobile learning the Internet is used as a platform, which is fast and convenient. When confronted with problems, they would not reflect independently first, instead they turned to the Internet for the answers, which led to their dependence on mobile learning devices and inertia of thinking.

S5: The learning files uploaded by the teacher are downloaded but not read or just browsed.

S6: The Internet search is very convenient nowadays, and the problems encountered can be solved basically with the help the searching website Baidu. If Baidu can not help me out, I will turn to the teacher or other students for help.

5.3.3 Impact of mobile learning on emotional engagement of pre-service chemistry teachers

Among the 129 learners of the course Chemistry Pedagogy based on mobile learning, 72.8% of the respondents said that they were very happy with the teacher, 62.8% said that they could quickly and accurately answer the questions in the QQ group, 57.4% said that their interest had been improved in learning, 55.1% said that it was very pleasant to communicate with the teacher and students, 52.0% said that using mobile devices in learning the course made them feel happy, and 51.2% said that the class was no longer boring.

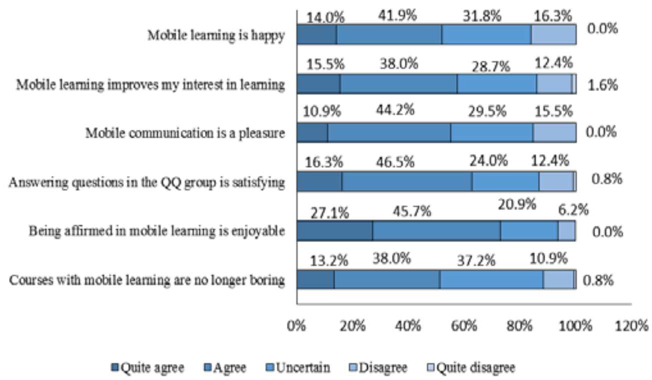

Fig. 5. Statistics of emotional engagement in the course Chemistry Pedagogy based on mobile learning

The survey results based on the questionnaires of Class A and Class B showed that the emotional engagement of Class A(M=3.72) was slightly lower than that of Class B(M=3.75), and the internal difference of Class A (SD=0.576) was smaller than that of Class B (SD=0.673) (see Table 6). Taking the class as an independent variable, and the students' emotional engagement as a dependent variable, we conducted the sample t test. Table 6 shows that the variance was homogeneous by the t test, with t=-0.292, p=0.771>0.05, indicating that there was no significant difference in emotional engagement between Class A and Class B. The previous assumption of H2c was proved invalid.

Mobile learning had a great influence on the improvement of the interest of pre-service chemistry teachers in the initial stage of teaching. With the decline of "freshness", their interest in mobile learning gradually declined. In addition, emotional engagement requires the exchange of emotions between teachers and students, while mobile learning is more based on the media, which is a barrier to face-to-face emotional communication between teachers and students.

S7: At the beginning, I felt that mobile learning was very novel. Kahoot! learning platforms were also very fun. Later, I became accustomed to them and gradually lost interest.

S8: When I was in the actual class, I would look up at the teacher from time to time, trying to have eye contact with the teacher. There is no such communication in mobile learning now, and mostly it is through smart phones that I communicate with the teacher.

6. Research findings and discussions

6.1 Support for the use of mobile learning from the pre-service chemistry teachers in the course Chemistry Pedagogy

Data obtained from the questionnaires, classroom observations and interviews show that pre-service chemistry teachers welcomed and supported the use of mobile learning technology in the course Chemistry Pedagogy. Most of them spent 2 hours or more per week using mobile learning devices for course announcements, course learning resources and classroom interactions inside and outside the classroom. Most pre-service teachers believed that mobile learning can effectively help them have deep learning and promote their cognitive development, and they had pleasant emotions in mobile learning. This is consistent with the conclusions of other scholars on mobile learning in higher education.

6.2 The engagement in the course Chemistry Pedagogy based on mobile learning is acceptable

The overall average engagement of the pre-service chemistry teachers in the course Chemistry Pedagogy based on mobile learning was acceptable. Behavioral engagement, cognitive engagement and emotional engagement were mutually highly positively correlated, but behavioral engagement was significantly higher than the cognitive engagement and emotional engagement.

6.3 Mobile learning significantly promoted behavioral engagement in the course Chemistry Pedagogy

The behavioral engagement of pre-service teachers in the course Chemistry Pedagogy based on mobile learning technology was significantly higher than that of the traditional course Chemistry Pedagogy, indicating that mobile learning has a significant role in promoting the learners' engagement in the course Chemistry Pedagogy. The information announcing system, learning resource system and interactive evaluation system constructed jointly by the Cloud platform, social medias and online questionnaire platforms promoted the behavioral engagement of pre-service teachers in the course Chemistry Pedagogy, and the characteristics of timely feedback and specific targeted comments also enhanced their behavioral engagement. In the course Chemistry Pedagogy based on mobile learning, pre-service chemistry teachers actively engaged in the learning activities inside and outside of the classroom in the form of information acquisition, answering, discussion and reflection.

6.4 Carefully designing teaching to deepen cognitive engagement of pre-service chemistry teachers

The cognitive engagement of pre-service teachers in the course Chemistry Pedagogy using mobile learning technology was not significantly higher than the traditional course Chemistry Pedagogy, indicating that mobile learning does not necessarily promote cognitive engagement in the course Chemistry Pedagogy. Fragmented ubiquitous learning and too much dependence on information retrieval based on mobile technology can lead to a shallow and fragmented understanding of concepts, which is difficult to promote deep learning and development of high-order thinking of pre-service teachers (Friesen & Lowe, 2011). Therefore, when carrying out mobile learning in teacher education programs, it is necessary to design a reasonable mobile learning plan both theoretically and practically, not only informing the pre-service teachers of the rapid development of mobile technology as a learning device, but also informing them of the values of mobile technology in teaching and the effective technology integration strategies. Starting from choosing the preferred mobile learning technology, selecting typical learning contents, setting up driving learning projects with appropriate difficulty, and offering personalized real-time evaluation feedback, teachers design the teaching carefully to stimulate the cognitive initiative of learners and help them to construct a meaningful sharing culture in the task of solving certain challenges(Jenkins, Ito & Boyd, 2016), to motivate pre-service chemistry teachers to engage in discussion, interpretation, sharing and reflection, and proactively construct cognition, which triggers their deep cognitive engagement. At the same time, it is necessary to guide the self-monitoring of pre-service teachers to help them overcome the interference of entertainment information in mobile terminals.

6.5 Overcoming the emotional barriers generated by technical exchanges to promote emotional engagement of pre-service chemistry teachers

In the course Chemistry Pedagogy based on mobile learning, the emotional engagement of pre-service chemistry teachers was lower. The first reason can connect with the decreasing eye contact between the teacher and students owing to mobile terminals, and the second reason can go to the fact that what mobile learning brings is shallow levels of pleasure and interest. It is recommended for the teacher to adopt the following four strategies to improve emotional engagement of students in teacher education programs: 1) Combine various advantages of mobile learning technology and use typical techniques to improve classroom teaching quality and efficiency; 2) Carefully design teaching contents, balance learning difficulty, and stimulate the long-term and stable learning motivations of pre-service chemistry teachers; 3)Control the duration of mobile learning (preferably within 10 minutes). In a Stanford University research, it has been found that students are easily distracted if they use mobile learning devices for a long time; 4)Offer timely specific immediate feedback through mobile learning devices to meet the professional development needs of pre-service chemistry teachers.

7. Research innovation and prospects

In terms of mobile learning, teacher education has always been a less researched area. This study is the first one to study pre-service teachers' engagement in the course Chemistry Pedagogy based on mobile learning, establish detailed measurement indicators of their engagement in the classroom based on mobile learning, explore their real engagement in the mobile learning environment, and analyze the relationship between behavioral engagement, cognitive engagement and emotional engagement to find out the impact of mobile learning on pre-service teachers' engagement. Different from previous studies focusing on the variables of mobile learning motivations, learning satisfaction, learning effects, etc., this study focused on the characterization of the variables in the learning process. It can not only complement the theory of mobile learning, but also provide practical examples for the integration of information technology into teacher education programs.

The importance and necessity of lifelong learning has been generally recognized. Mobile learning has the characteristics of convenience, efficiency, mobility and universality which makes it easy for people to learn anywhere and anytime and it is conducive to the realization of lifelong learning. Through this study we found that mobile learning has a significant effect on promoting the engagement of pre-service teachers in teacher education courses and no significant impact on their cognitive engagement, especially on their deep and high-level cognitive engagement, and the emotional barriers generated in the process of mobile learning even had the risk of weakening their emotional engagement. But it is without any denying that the behavioral engagement, cognitive engagement and emotional engagement are mutually highly positively correlated. Accordingly, it can be predicted that the integration of technology into education can not only promote behavioral engagement but also have the potential of improving cognitive engagement and emotional engagement. Therefore, further research should focus on how to promote deep and high-level cognitive engagement through mobile learning and how to promote positive emotional engagement.

8. Limitations

There were some significant limitations to the current study. First, we only choose 177 learners as participants in a limited learning time in this exploratory study. As time passes, ideally more participants will register in courses, and then we can observe pre-service teachers' engagement on a larger scale. Second, the present study examined pre-service teachers in a specific course. There may have been sample bias in that all participants were pre-service teachers who had an interest in taking a course focused on college success. Although taking a domain- or course-specific perspective enhances the internal validity of research on pre-service teachers' engagement, future research could establish the broader applicability of the findings by examining the comparative fit of the model across multiple contexts. Third, the data were collected mainly by self-report measures which typically ask participants to respond to contextually dependent questions, however this occurs after the participant is no longer within the context of interest, which can compromise the validity of responses (Hektner, Schmidt, & Csikszentmihayli, 2007). According to the research conducted by Xie, Heddy, and Greene (2019), there were not major differences between in the moment self-reported engagement and the more traditional prospective or retrospective measures, but there were differences between the self-reported and college students' actual behavioral engagement. For example, students often overestimate the time they spend on studying for Saturdays and also late nights and tend to report more desired outcomes in prospection and retrospection than their responses in the moment. Although students' own perceptions of their engagement reflect the important bearing of self-beliefs on motivation and behavior, future researchers could provide additional insight by gathering engagement data in the moment of studying using experience-sampling methodology (ESM).

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References

Aubusson, P., Schuck, S., & Burden, K. (2009). Mobile learning for teacher professional learning: Benefits, obstacles, and issues. ALT-J, *Research in Learning Technology*, 17(3), 233–247.

Baran, E. (2014). A review of research on mobile learning in teacher education. *Educational Technology &Society*, 17(4),17-32.

Bates, C. C., & Martin, A. (2013). Using mobile technology to support literacy coaching practices. *Journal of Digital Learning in Teacher Education*, 30(2), 60–66.

Burch, G. F., Heller, N. A., Burch, J. J., Freed, R., & Steed, F. A. (2015). Student Engagement: Developing a Conceptual Framework and Survey Instrument. *Journal of International Students*,8(2),224-229.

Cao, X. F., Masood, A., Luqman, A., & Ali, A. (2018).Excessive use of mobile social networking sites and poor academic performance: Antecedents and consequences from stressor-strain-outcome perspective. *Computers in Human Behavior*, 85,163-174.

Chee, K. N., Yahaya, N., Ibrahim, N. H., & Noor H. M. (2017) . Review of mobile learning trends 2010-2015: A meta-analysis. *Educational Technology & Society*, 20(2),113-126.

Chen, C. (2010). The implementation and evaluation of a mobile self- and peer-assessment system. *Computers & Education*, 55(1), 229–236.

Churchill, D., & Wang, T. (2014). Teacher's use of iPads in higher education. *Educational Media （a） International,* 51(3), 214–225.

Crippen, K. J., & Brooks, D. W. (2000). Using personal digital assistants in clinical supervision of student teachers. *Journal of Science Education & Technology*, 9(3), 207–211.

Cushing, A. (2011). A case study of mobile learning in teacher training–Mentor ME (Mobile enhanced mentoring). *Medien Pädagogik*, 19, 1–4.

Ekanayake, S. Y., & Wishart, J. (2014). Integrating mobile phones into teaching and learning: A case study of teacher training through professional development workshops. *British Journal of Educational Technology*. 46(1):173-189.

Engin, M., & Donanci, S. (2015). Dialogic teaching and iPads in the EAP classroom. *Computers & (a) Education,* 88, 268–279.

Foulger, T. S., Burke, D., Williams, M. K., Waker, M. L., Hansen, R., & Slykhuis, D. A. (2013). Innovators in teacher education: Diffusing mobile technologies in teacher preparation curriculum. *Journal of Digital Learning in Teacher Education*, 30(1), 21–29.

Franklin, T., Sexton, C., Lu, Y., & Ma, H. (2007). PDAs in teacher education: A case study examining mobile technology integration. *Journal of Technology and Teacher Education,* 15(1), 39–57.

Friensen, N., & Lowe, S. (2011). The questionable promise of social media for education: Connective learning and the commercial imperative. *Journal of Computer Assisted Learning*,28,183-194.

Gikas, J., & Grant, M. M. (2013). Mobile computing devices in higher education: Student perspective on learning with cellphones, smartphones & social media. *Internet and Higher Educatio*n, 19, 18–26.

Hektner, J. M., Schmidt, J. A., & Csikszentmihalyi, M. (2007). Experience sampling method: Measuring the quality of everyday life. Sage.

Herro, D., Kiger, D., & Owens, C. (2013). Mobile technology: Case-based suggestions for classroom integration and teacher educators. *Journal of Digital Learning in Teacher Education*, 30(1), 30–40.

Husbye, N. E., & Elsener, A. A. (2013). To move forward, we must be mobile: Practical uses of mobile technology in literacy education courses. *Journal of Digital Learning in Teacher Education*, 30(2), 46–51.

Järvelä, S., Näykki, P., Laru, J., & Luokkanen, T. (2007). Structuring and regulating collaborative learning in higher education with wireless networks and mobile tools. *Educational Technology & Society*, 10(4), 71–79.

Jenkins, H., Ito, Mo., & Boyd, D. (2016). Participatory culture in a networked era. A conversation on youth, learning, commerce and politics. Cambridge: Polity Press.

Kearney, M., & Maher, D. (2013). Mobile learning in math teacher education: Using iPads to support pre-service teachers' professional development. *Australian Educational Computing*, 27(3), 76–84.

Kommers, P. (2009). Mobile phones for real-time teacher coaching. *Journal of Research in Innovative Teaching*, 2(1), 80–90.

Kukulska-Hulme, A., Sharples, M., Milrad, M., Arnedillo-Sánchez, I., & Vavoula, G. (2009). Innovation in mobile learning: A European perspective. *International Journal of Mobile and Blended Learning*, 1(1), 13–35.

Lepp, A., Barkley, J., & Karpinski, A. (2015). The relationship between cell phone use and academic performance in a sample of U.S. College students. Sage Open, January-March,1,9.

Lim, T., Fadzil, M., & Mansor, N. (2011). Mobile learning via SMS at Open University Malaysia: Equitable, effective and sustainable. *The International Review of Research in Open and Distributed Learning*, 12(2), 122–137. https://doi.org/10.19173/irrodl.v12i2.926.

Looi, C., Sun, D., Seow, P., & Chia, G. (2014). Enacting a technology-based science curriculum across a grade level: *The journey of teachers' appropriation. Computers & Education*, 71, 222–236.

Looi, C.K., Sun, D., Kim, M.S., & Wen, Y. (2018).The impact of a professional development model for a mobilized science curriculum: a case study of teacher changes. *Research in Science & Technological Education*,36(1),86-110.

Mac, C. K., Jeffrey, L., & Kinshuk. (2014). Factors impacting teachers' adoption of mobile learning. *Journal of Information Technology Education: Research*,13,141-162.

McCaughtry, N., & Dillon, S. R. (2008). Learning to use PDAs to enhance teaching: The perspectives of preservice physical educators. *Journal of Technology and Teacher Education*, 16(4), 483–503.

Nikou, S. A., & Economides, A. A. (2018). Mobile-based assessment: A literature review of publications in major referred journals from 2009 to 2018. Computers & Education,125,101-119.

Ozdamli, F., & Cavus, N. (2011). Basic elements and characteristics of mobile learning. *Procedia-Social and Behavioral Sciences*, 28.

Pedro, L. F. M. G., Barbosa, C. M. M. O., & Santos, C. M. N. (2018). A critical review of mobile learning integration in formal educational contexts. *International Journal of Educational Technology in Higher Educaiton*,15,10.

Rogers, Y., & Price, S. (2008). The role of mobile devices in facilitating collaborative inquiry in situ. *Research and Practice in Technology Enhanced Learning*, 3(3), 209–229

Ronel, C. (2018). Developing Mobile Teaching Practice: A Collaborative Exploration Process. *Technology Know Learn*,23,331-350.

Schuck, S., Aubusson, P., Kearney, M., & Burden, K. (2013). Mobilizing teacher education: A study of a professional learning community. *Teacher Development*, 17(1), 1–18.

Seppälä, P. P., & Alamäki, H. H. (2003). Mobile learning in teacher training. *Journal of Computer Assisted Learning*, 19(3), 330–335.

Shotsberger, P. G. (2003). Mobile wireless technologies for field-based teacher interns and their partnership teachers, computers in the schools. Interdisciplinary Journal of Practice, Theory, and Applied Research, through professional development workshops. *British Journal of Educational Technology*, 19(3-4), 49–65.

Song, Y., Wong, L.-H., & Looi, C.-K. (2012). Fostering personalized learning in science inquiry supported by mobile technologies. *Education Technology Research Development*, 60(4), 679–701.

Sung, Y., Chang, K., & Liu, T. (2016). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. *Computers & Educcation*,94,252-275.

Tess, P. (2013). The role of social media in higher education classes (real and virtual) – A literature review. *Computers in Human Behavior*, 29,60-68.

Tezer, M., & Beyoğlu, D. (2018). How do Preservice Teachers' Readiness and Attitudes towards Mobile Learning Affect their Acceptance of Mobile Learning Systems? *TEM Journal* ,7(4),875-885.

Valtonen, T., Havu-Nuutinen, S., Dillon, P., & Vesisenaho, M. (2011). Facilitating collaboration in lecture-based learning through shared notes using wireless technologies. *Journal of Computer Assisted Learning*, 27(6), 575–586.

Viberg, O., & Grönlund, Å. (2013). Cross- cultural analysis of us‐ers' attitudes toward the use of mobile devices in second and for‐eign language learning in higher education: A case from Sweden and China.*Computers & Education*,69.

Virtanen, T. E., Lerkkanen, M. K., & Poikkeus, A. M. (2015). The relationship between classroom quality and students' engagement in secondary school. Educational Psychology,35(8),963-983.

Wang, P. (2017). Research on model of student engagement in online learning. *Eurasia Journal of Mathematics Science and Technology Education*,13(7),2869-2882.

Wu, Q. (2015). Designing a smartphone app to teach English (L2) vocabulary. Computers & Education, 85, 170–179.

Wu, W., Wu, Y., Chen, C., Kao, H., Lin, C., & Huang, S. (2012). Review of trends from mobile learning studies: A meta-analysis. *Computers & Education*,59,817-827.

Xie, K., . Heddy, B. C., & Greene, B. A.(2019). Affordances of using mobile technology to support experience-sampling method in examining college students' engagement s. *Computers & Education*, 128, 183-198.

Yazzie- Mintz, E. (2007). Voices of Students on Engagement: A Report on the 2006 High School Survey of Student Engagement. Bloomington, IN: *Center for Evaluation & Education Policy*, 1,10-11.

Shirky, C. (2014). Why I just asked my students to put their laptops away. Retrieved from https://medium.com/@cshirky/why-i-just-asked-my-stuednts-to-put-their-laptops-away-7f5f7c50f368

Sana, F., Weston, T., & Cepeda, N. J. (2013). Laptop multitasking hinders classroom learning for both users and nearby peers. *Computers & Education*, 62,24-31.