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ARTICLE

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Chinese undergraduate students' perceptions of mobile learning: Conceptions, learning profiles, and approaches

Xiao-Fan Lin[1] | Cailing Deng[1] | Qintai Hu[1] | Chin-Chung Tsai[2,3]

[1] School of Education Information Technology, South China Normal University, Guangdong Provincial Engineering and Technologies Research Centre for Smart Learning, Guangzhou, China

[2] Program of Learning Sciences, National Taiwan Normal University, Taipei, Taiwan

[3] Institute for Research Excellence in Learning Sciences, National Taiwan Normal University, Taipei, Taiwan

Correspondence
Qintai Hu, Guangdong Provincial Engineering and Technologies Research Centre for Smart Learning, Office 214, South China Normal University, 55 Zhongshan Dadao Xi, 510631 Guangzhou, China.
Email: 2013010048@m.scnu.edu.cn

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Abstract

Close links between students' conceptions of and approaches to learning were established in the past research. However, only a few quantitative studies investigated this relationship particularly with regard to mobile learning (m-learning). The correlation between learners' conceptions and approaches to m-learning was analysed using a partial least squares analysis applied to data obtained from a sample of 971 undergraduate students in China. The results indicated that students' conceptions of m-learning could be classified into reproductive, transitional, and constructive levels. Students may hold multiple m-learning applications than a predominant one; hence, examining m-learning as one monolithic entity may provide limited information. Latent profile analysis identified four learning profiles based on students' preferred m-learning applications: passive, mixed, surface-supportive, and high-engagement.. Moreover, a general trend was observed, whereby students with reproductive and surface-supportive learning profiles showed a tendency to adopt surface approaches, whereas those expressing constructive and mixed learning profiles were more inclined to adopt deep approaches. Interestingly, students with transitional conceptions and high-engagement learning profiles tended to take both surface and deep approaches.

KEYWORDS

approaches to m-learning, conceptions of m-learning, latent profile analysis, mobile learning profiles, partial least squares analysis

1 | INTRODUCTION

Students' conceptions of learning (i.e., students' internal representation of how to learn on their own) have been studied since Säljö (1979). These studies found that the conceptions of learning are related to the learning process, such as how to choose a cognitive strategy and then understand how that strategy functions (P. S. Tsai, Tsai, & Hwang, 2011b). Several studies also reported that conceptions of learning are important issues in educational research because they significantly influence undergraduate students' learning approaches and results (Ellis, Goodyear, Prosser, & O'Hara, 2006; C. C. Tsai & Tsai, 2013). In response to the increasing reliance on wireless iInternet and mobile devices, Hsieh and Tsai (2017) have turned their attention to m-learning and revealed identified six qualitatively different conceptions of m-learning. Accordingly, the use of mobile devices in learning, which includes student negotiation, problem solving in a situated learning environment, and pervasive learning with location-based authentic learning materials, is widely adopted by undergraduate students (Crompton, Burke, Gregory, & Gräbe, 2016). Furthermore, each individual is likely to utilise a number of m-learning applications. (Purdie & Hattie, 2002; Vermunt & Vermetten, 2004); hence, examining m-learning as one monolithic entity may provide limited information. The study aims to distinguish m-learning profiles according to the critical applications of m-learning. Furthermore, it is essential to study students' perceptions of m-learning through conceptions, applications, and their roles in approaches to m-learning, which may provide benefits for both teachers and students, particularly those who would like innovative practices.

2 | LITERATURE REVIEW

2.1 | Research on conceptions of m-learning

Conceptions of learning are defined as one's beliefs and understandings of the nature of learning (Chiou, Lee, & Tsai, 2013) belonging to the research field of epistemic beliefs. Individual epistemic beliefs are continually changing, and hierarchical classification ranges from absolutist beliefs to sophisticated beliefs about knowledge (C. C. Tsai, Ho, Liang, & Lin, 2011). Table 1 shows the theoretical development framework of the conceptions of learning. In Table 1, the significance of epistemic beliefs for learning has particularly been demonstrated in educational research involving technology-mediated situations ranging from conceptions of learning and online learning to conceptions of mobile and ubiquitous learning (u-learning).

Richardson (2013) demonstrated through literature review that parallels reside between the conceptions of learning, and there is analogous epistemic development from different points of view (e.g., learner, teaching, knowledge, and understanding). For instance, Van Rossum and Hamer (2010) presented six different aspects of educational conceptions (learning conceptions, objects of reflection, teaching conceptions, conceptions of understanding, conceptions of applying, and conceptions of intelligence, respectively) and identified that they all developed hierarchically. As for the conceptions of learning, they have been documented as a hierarchical framework, and their variations may be relevant to different educational settings (C. C. Tsai, Ho, et al., 2011). C. C. Tsai (2009) classified undergraduate students' conceptions of learning into seven categories, namely, "memorizing," "status," "calculating," "understanding," "increase," "applying," and "seeing in a new way." The analysis showed that among all the conceptions, 'memorizing,' 'status,' and 'calculating' were categorized as reproductive conceptions of learning, while the remaining categories were classified as constructive conceptions.

Several studies have observed that the improvement of students' conceptions of learning is equivalent to a shift from reproductive to constructive conceptions of learning (e.g., Lee, Johanson, & Tsai, 2008; C. L. Lin, Tsai, & Liang, 2012; C. C. Tsai, 2004). T. J. Lin, Liang, and Tsai (2015b) characterized conceptions of learning physics into three-level perceptions based on the results of a cluster analysis, introducing the reproductive, transitional, and constructive profiles. Their study was consistent with past studies (-Brownlee, Walker, Lennox, Exley, & Pearce, 2009; Kember, 1997) that sought a transitional orientation to connect the two primary directions (T. J. Lin et al., 2015b).

After investigating existing literature on conceptions of learning and teaching, Van Rossum and Hamer (2010) emphasized hard work as crucial to a definitive transformation from reproductive to reconstructive conceptions. Hsieh and Tsai (2017) recently demonstrated that teacher–student conceptions of m-learning formed a hierarchy and showed an approach moving from teacher-/content-centred to learner-/learning-centred conceptions. It is probable that students would like multiple applications of m-learning among learning activities. Thus, studies could be undertaken to characterize students in accordance with their most critical m-learning applications so as to indicate several different m-learning profiles that could reveal a framework of various applications.

TABLE 1 Theoretical development framework of the conceptions of learning

	Conceptions of learning	Conceptions of online learning			Conceptions of ubiquitous and mobile learning	
Range of conceptions	Eklund-Myrskog (1998)	Tsai (2004)	Tsai (2009)	Ellis, Goodyear, Calvo, and Prosser (2008)	Tsai, Tsai, and Hwang (2011a)	Hsieh and Tsai (2017)
Constructivist ↑	Forming a conception of one's own	Seeing in a new way	Seeing in a new way	Filtering different perspectives to promote deeper thought to meet intrinsic requirements	Active learning	Extending learning beyond school
	Getting a new perspective	Understanding	Understanding	The development of ideas to create new awareness to meet intrinsic requirements	A timely guide	Focusing on student ownership
↓	Applying knowledge	Applying	Applying	A way of sharing ideas to meet extrinsic requirements	Increase of knowledge	Parting from traditional teaching
Reproductive	Understanding	Increases of knowledge	Increase	A way of meeting extrinsic requirements	A platform for attaining information	Invigorating and enhancing learning
	Memorizing	Calculating and practicing tutorial problems	Calculating and practicing	A way of meeting extrinsic requirements	The application of technology	Conducting classes with efficiency
		Preparing for test	Getting a better status			Meeting students' preferences
		Memorizing	Memorizing			

2.2 | Research on critical applications used in m-learning

In considering the applications used in m-learning, T. D. Jong, Specht, and Koper (2008) put forward five separate dimensions of a reference model as follows: content, context, purpose, information flows, and pedagogical paradigms. Deegan and Rothwell (2010) further summarized several classifications of m-learning to understand specific issues, challenges, and benefits of applications delivered in the m-learning process. Among the categories of m-learning applications proposed by Deegan and Rothwell (2010), three critical ones were worth paying further attention to when identifying the differential contribution of applications used in m-learning.

The first is 'content-based' application, which refers that learners prefer to regard m-learning as being able to access and store multimedia learning resources (e.g., e-books, test files, online courses, and video clips) using internet-connected devices like their smartphones (Cheung & Hew, 2009). In East Asian countries, like China, are partial to this type of m-learning owing to cultural influences and specific educational contexts. For instance, many Chinese learners use smartphones to watch, listen to, and memorize learning materials anytime and anywhere in preparation for highly competitive examinations (Lin, Liang, Tsai, & Hui, 2018).

The second important application highlighted here is the "supportive" one, which refers to employing handheld devices to communicate through a direct communication between participants (Churchill & Churchill, 2007) and information gathering to survey or check for the understanding of the presented content. Email and short messaging service (SMS) are a kind of standard technology on all mobile phones that provides a simple way of forming a feedback loop between teacher and student (Deegan & Rothwell, 2010). Social networking applications, such as Twitter, WhatsApp, and Facebook, are also widely used synchronously and asynchronously through undergraduate students.

Finally, 'collaborative' application refers to learners who actively participate in the learning process by collaborating with other learners and teachers through smartphones. This is considered as one of the critical notions of m-learning. Besides, it is seen to be positively relevant to improvement in students' learning performance. S. Y. Jong and Tsai (2016) described an outdoor social inquiry learning activity through mobile applications, where students acquired and built their knowledge by interacting within a group. The first-hand data by gathering through smartphones were promptly interpreted. Then the processed information was fed back to the group members such that they could immediately see the results of their collaborative work. Thus, they categorized applications used in m-learning into three aspects, which included "content-based," "supportive," and "collaborative," and these applications could be regarded as the crucial ones when examining learners' m-learning profiles.

2.3 | Research on approaches to m-learning

Approaches to m-learning can be defined as the way that learners employ mobile technology to facilitate their learning tasks and affect their outcomes. The aim of this construct was to interpret the main reasons for learners' different achievements in similar m-learning contexts. Two predominant modes in approaches to learning have been considered in previous educational studies: deep and surface approaches (e.g., C. Chin & Brown, 2000; W. T. Li, Liang, & Tsai, 2013). In Chiou, Liang, and Tsai's (2012) study, the surface approaches were connected to the extrinsic motivation for learning, and less advanced cognitive activities, such as mechanical learning, were associated with the memorization of fragmented knowledge" in the last paragraph, Please change the location of this sentence. The beginning sentence of next paragraph should be "Approaches to learning have generally been extensively surveyed in various domains, such as physics (T. J. Lin et al., 2015b) and chemistry (W. T. Li et al., 2013).

Approaches to learning have generally been extensively surveyed in various domains, such as physics (T. J. Lin et al., 2015b) and chemistry (W. T. Li et al., 2013). Furthermore, given the nature of different environments, merit can be found in exploring students' approaches to learning when addressing web-based learning. For example, Yang and Tsai (2010) revealed a consistent result from educational literature that surface approaches squint towards associated with lower quality performance, whereas deep approaches are relevant to higher quality performance. This study formulates categories of approaches for m-learning based on this premise.

2.4 | The relationships among conceptions of, applications of, and approaches to m-learning

Previous studies confirmed that students in favour of reproductive conceptions of learning (e.g., testing, calculating, and practicing) are inclined to adopt surface approaches to learning, whereas those with constructive conceptions (e.g., understanding, applying, and seeing in a new way) tend to employ deep approaches (Ellis et al., 2006; Lee et al., 2008). For instance, Lee et al. (2008) found that reproductive conceptions of learning science (i.e., testing, calculating, and practicing) were tied closely with learners' surface approaches to learning science, whereas constructivist conceptions (i.e., applying, understanding, and seeing in a new way) were highly pertinent to deep approaches. Many researchers drew a similar conclusion from the viewpoint of different subjects, such as physics (T. J. Lin et al., 2015b), biology (Chiou et al., 2012), and computer science (Liang, Su, & Tsai, 2015).

Along with the development of information technology, more studies were concerned about the correlations between the conceptions of and approaches to learning regarding specific situations in an online environment (e.g., online argument and online peer assessment). Yang and Tsai (2010) revealed two hierarchically associated and qualitatively different conceptions of learning via an online peer assessment linked with surface and deep approaches. Other studies reported the associations between learners' conceptions of and approaches to learning using online peer assessments (Cheng & Tsai, 2012), as well as a connection to learning performance (Yang & Tsai, 2010). Tsai and Tsai (2013) indicated that students, who perceived conceptions of online argumentation as an approach of simply expressing thoughts, might show a tendency to adopt surface approaches (e.g., "posting different ideas"). By contrast, those holding the conceptions of emphasizing online argumentation as a solution of making reflections or negotiating thoughts were inclined to adopt deep approaches (e.g., "evaluating postings for challenging thoughts and reflecting thoughts carefully"). In addition, Yang and Tsai (2017) found that teacher–learners with conceptions of online education as a mere means to achieve a diploma tended to accept surface approaches ("interacting with people"). However, those with the conception of "lifelong learning" are likely to adopt deep approaches ("getting involved in the community of sharing"). This evidence shows that future studies may emphasize the relationship between conceptions of and approaches to certain learning related to emerging technologies.

The popularity of mobile computing devices in the 21st century creates opportunities for interaction, collaboration, and communication through mass media and Web 2.0 applications with the assistance of timely connectivity (e.g., Ke & Hsu, 2015). Moreover, mobile applications might situate students in a real-life context for better perceptions of learning (Hwang, Tsai, Chu, Kinshuk, & Chen, 2012). Students may perceive multiple m-learning applications rather than a predominant one, which make significant differential contributions to the way students study, whether they use surface cognitive processes or deep cognitive processes or both in their learning. Hence, it is of paramount importance that researchers investigate student m-learning applications to distinguish different m-learning profiles and their role in approaches to m-learning.

In light of these aforementioned studies, the current research has three purposes: (a) to reveal students' conceptions of, applications of, and approaches to m-learning; (b) to report on relationships between conceptions of and approaches to m-learning; and (c) to distinguish m-learning profiles in terms of the crucial m-learning applications and further compare students' approaches with m-learning among different profiles.

2.5 | Research questions

This study aimed at the factors pertaining to students' m-learning profiles and approaches to m-learning. The research questions are as follows:

- How do undergraduate students in China perceive m-learning in terms of conceptions, applications, and approaches?
- Using partial least squares (PLS) analysis, are Chinese undergraduate students' conceptions of m-learning predictive of their approaches to m-learning?
- In terms of the three core applications, how do the m-learning profiles of Chinese undergraduate students correspond their approaches to m-learning?

3 | METHODS

3.1 | Participants

The participants comprised 971 undergraduate students (665 women and 306 men). However, most of the participants came from teacher education institutes, where women occupied a large percentage. In China, numerous women students aspire to become teachers and enter into preservice universities or institutes. The ages of the samples ranged from 17 to 23 (mean = 20.53, standard deviation = 0.96). Among all participants, 37.2% students majored in physics, 29.2% students majored in biology, 16.5% students majored in engineering, and 17.1% students majored in chemistry. Participants were conveniently sampled from 18 colleges (and universities) in the Higher Education Mega Centre in southern China. The participants were science- and engineering-related majors and required to complete online learning courses in basic science and engineering to be qualified for a series of more advanced courses. Therefore, all participants had previous exposure to learning projects, where mobile devices were utilized for teaching and learning (i.e., projects occupying more than one third of the class time). For instance, several m-learning activities were included in a mixed m-learning project. Aside from studying disciplinary knowledge in the classroom, students were encouraged to understand what they were learning outdoors by capturing photos or videos of the real-life context and inquiry process using smartphones. They would then upload the photos with words to the community website (e.g., a wiki), and some tasks (e.g., online sharing, discussions, and peer assessment) will occur to facilitate learners' understanding of the learning materials.

3.2 | Conceptions of m-learning questionnaire

The conceptions of m-learning questionnaire originated from the web-based conceptions of learning management questionnaire (H. M. Lin & Tsai, 2011) and the conceptions of ubiquitous learning questionnaire (P. S. Tsai, Tsai, & Hwang, 2011a). Table 2 shows the interpretation and sample items of six scales: (a) capture tools for memorization, (b) assessment tools for testing, (c) efficient tools for achieving a higher status, (d) focusing on continuous learning, (e) the application of extended ideas, and (f) communication for enhancing understanding. Teachers allow students to be flexible by controlling their m-learning process (Hsieh & Tsai, 2017); hence, this study revised the conceptions of m-learning questionnaire by adding m-learning-related terms and content referring to Cheung and Hew's (2009) study. For instance, Table 2 contains the conception, "m-learning as assessment tools for testing," which was adapted based on the "testing" dimension in H. M. Lin and Tsai's (2011) study and the classifications of m-learning tools in Cheung and Hew's (2009) study, insofar as college students are permitted to use phones or tablets for examinations outside the classroom. In addition, a pilot study collected responses from undergraduate students to judge the suitability of using these particular constructs and items. Several questions were reworded based on the pilot results. Moreover, three experts in m-learning and education research were invited to examine both the surface and content validities of the revised questionnaire. The conceptions of m-learning questionnaire was slightly modified following the abovementioned procedure.

TABLE 2 The description of conceptions of m-learning

Construct	Description	Example item
m-learning as capture tools for memorization (M)	In this category, the students view the employment of mobile devices as a way to memorize definitions, equations, theorems, and special terms, such as the application of the note-taking and voice functions.	In my view, m-learning means using mobile devices (such as playing at any time and watching repeatedly) to help me to memorize important content.

Table 3 displays that the conceptions of m-learning were grouped into the following six orthogonal structures after an exploratory factor analysis (EFA): assessment tools for testing (four items), efficient tools for achieving a higher status (five items), application of extended ideas (five items), capture tools for memorization (four items), communication for enhancing understanding (four items), and focusing on continuous learning (three items). The total variance explained is 66.47%, and the overall α was 0.89.

A study conducted by C. C. Tsai, Ho, et al. (2011) demonstrated that "memorizing" and "testing" belong to reproductive conceptions, whereas "applying" and "understanding" belong to constructive conceptions using a confirmatory factor analysis (CFA). Hence, this study assumes that "m-learning as capture tools for memorization" and "m-learning as assessment tools for testing" are reproductive conceptions of m-learning and that "m-learning as the application of extended ideas" and "m-learning as communication for enhancing understanding" are constructive conceptions of m-learning. However, neither reproductive nor constructive perspectives could exactly explain "m-learning as efficient tools for achieving a higher status" and "m-learning as focusing on continuous learning." These were regarded as both reproductive and constructive conceptions (H. M. Lin & Tsai, 2011; P. S. Tsai, Tsai, & Hwang, 2011a) and classified as "transitional" conceptions of m-learning (T. J. Lin et al., 2015b). Therefore, this study proposes a possible hierarchical framework:

TABLE 3 Exploratory factor analysis of the conceptions of m-learning instruments

Construct	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Assessment tools for testing (T)						
T1	−0.04	**0.83**	0.12	−0.10	0.21	−0.08
T2	0.01	**0.81**	0.20	−0.05	0.17	−.010
T3	−0.08	**0.80**	0.18	−0.00	0.21	0.06
T4	−0.02	**0.78**	0.11	−0.02	0.29	0.02
Efficient tools for achieving a higher status (G)						
G1	−0.01	0.34	**0.73**	−0.02	0.19	0.15
G2	0.10	0.32	**0.71**	0.07	0.23	0.09
G3	0.22	0.13	**0.69**	0.20	0.14	−0.03
G4	0.28	0.10	**0.67**	0.22	0.15	−0.01
G5	0.20	0.02	**0.67**	0.24	0.10	0.19
Application of extended ideas (A)						
A1	**0.73**	−0.07	0.29	0.01	0.01	0.29
A2	**0.70**	−0.09	−0.03	0.38	−0.06	0.09
A3	**0.69**	0.01	0.26	0.25	0.03	0.13
A4	**0.69**	−0.03	0.19	0.44	−0.04	0.02
A5	**0.66**	0.03	0.16	0.25	0.12	0.20
Capture tools for memorization (M)						
M1	−0.02	0.24	0.17	−0.08	**0.80**	0.00
M2	0.08	0.14	0.17	0.09	**0.80**	0.02
M3	0.04	0.22	0.17	0.06	**0.79**	−0.01
M4	−0.05	0.24	0.10	0.11	**0.64**	0.04
Communication for enhancing understanding (U)						
U1	0.11	0.05	0.19	**0.70**	0.16	0.23
U2	0.32	−0.16	0.15	**0.69**	0.03	0.07
U3	0.32	−0.01	0.26	**0.69**	0.08	0.01
U4	0.28	−0.06	0.06	**0.65**	−0.01	0.20
Focusing on continuous learning (C)						
C1	0.22	0.03	0.19	0.158	0.067	**0.81**
C2	0.44	0.00	0.03	0.423	−0.008	**0.58**
C3	0.42	−0.04	0.04	0.433	−0.046	**0.57**

Note. KMO = 0.91, overall α = 0.89, total variance explained = 66.47%.
The bold texts represent that the value of factor loadings is above 0.5.

Reproductive conceptions of m-learning include "capture tools for memorization" and "assessment tools for testing"; transitional conceptions of m-learning include "efficient tools for achieving a higher status" and "focusing on continuous learning"; and constructive conceptions include "communication for enhancing understanding" and "application of extended ideas."

3.3 | Applications of m-learning questionnaire

The questionnaire for surveying students' m-learning applications was adapted and modified from Deegan and Rothwell's (2010) study. Based on their research, we selected content-based, supportive and collaborative as the three core applications. Three experts in m-learning validated the content of the scale items.

The descriptions of each subscale were illustrated as follows: (a) content-based, which defines the application that m-learning is being able to access and store multimedia learning resources; (b) supportive, which refers to the notions that m-learning is a series of supportive applications for direct communication between participants or information gathering to check the presented content; and (c) collaborative, which refers to the application that encourages learners to take an active part in the learning process, often by working with other learners or teachers. The questionnaire used in the research consisted of 17 items to reveal the participants' applications of content-based (five items), supportive (six items), and collaborative (six items) during m-learning activities. Each item was anchored on a 5-point Likert scale at 5 (*strongly agree*) and 1(*strongly disagree*).

3.4 | Approaches to m-learning questionnaire

Approaches to m-learning are characterized by deep and surface approaches in an m-learning environment. The questionnaire for these approaches was adapted from the study by Yang and Tsai (2010), in which approaches to learning via online peer assessment were discussed. In what follows, an interpretation of each category is given along with a sample item.

3.4.1 | Deep approaches

In this category, the students have deep motives (e.g., intrinsic interests) or deep strategies (e.g., maximizing meanings) to use mobile devices for m-learning. The example items are as follows:

Deep motives: When I start m-learning, I always find that the course content is very interesting.

Deep strategies: In the mobile environment, I am fond of applying new knowledge to practice.

3.4.2 | Surface approaches

The students in this category have surface motives (e.g., fear of failure and personal preference) or surface strategies (e.g., narrow targets and reproducing information) for m-learning. The example items are as follows:

Surface motives (SM): In the mobile environment, I am worried that my academic performance does not meet the expectations of teachers.

Surface strategies (SS): In my view, the best way to attain good grades with m-learning is to memorize the probable answers to questions if possible.

Table 4 shows that 26 items were retained in the questionnaire for approaches to m-learning after an EFA, and the overall α was 0.93. The retained structures were labelled with the following four structures: surface motives (eight items), surface strategies (six items), deep motives (six items), and deep strategies (five items). These structures explained 63.80% of the variance.

3.5 | Data analysis and procedure

Five steps were arranged herein to offer a comprehensive answer to the proposed research questions: the development of questionnaires

TABLE 4 Exploratory factor analysis of the approaches to m-learning instruments

Construct	Factor 1	Factor 2	Factor 3	Factor 4
Surface motives (SM)				
SM1	**0.79**	0.02	0.28	0.07
SM2	**0.78**	0.01	0.29	0.07
SM3	**0.77**	0.07	0.22	0.15
SM4	**0.76**	0.03	0.21	0.16
SM5	**0.75**	0.05	0.25	−0.06
SM6	**0.73**	0.13	0.16	0.17
SM7	**0.72**	0.08	0.10	0.13
SM8	**0.72**	0.16	0.23	−0.05
SM8	**0.65**	0.11	0.23	0.10
Surface strategies (SS)				
SS1	0.28	0.07	**0.77**	−0.03
SS2	0.25	0.00	**0.76**	0.03
SS3	0.32	0.03	**0.72**	−0.00
SS4	0.26	0.02	**0.66**	0.12
SS5	0.35	−0.17	**0.61**	0.25
SS6	0.36	−0.12	**0.60**	0.29
Deep motives (DM)				
DM1	0.12	0.19	0.04	**0.77**
DM2	0.06	0.21	−0.04	**0.76**
DM3	0.14	0.22	0.15	**0.64**
DM4	0.11	0.32	0.17	**0.62**
DM5	0.09	0.41	0.04	**0.60**
DM6	0.02	0.43	0.26	**0.53**
Deep strategies (DS)				
DS1	0.06	**0.79**	−0.05	0.19
DS2	0.06	**0.78**	0.03	0.24
DS3	0.07	**0.76**	−0.05	0.27
DS4	0.14	**0.74**	−0.05	0.26
DS5	0.09	**0.72**	0.01	0.17

Note. KMO = 0.89, overall α = 0.91, total variance explained = 63.80%. The bold texts represent that the value of factor loadings is above 0.5.

for conceptions of and approaches to m-learning, the finalization of questionnaires for conceptions of and approaches to m-learning, and the exploration of the correlation between the two factors mentioned above (Figure 1). As shown in Figure 1, an EFA and a CFA were conducted to finalize the questionnaires. For the first step, the samples (*n* = 971) were randomly separated into two subsets for the EFA (*n* = 489) and CFA (*n* = 482). EFAs were utilized to examine the factor structures in the samples. The last-two-steps approach suggested by W. W. Chin (1998) was conducted for the PLS analysis. For the second step, a CFA was applied to evaluate the measurement model to assess the reliability, validity, and structure of the two questionnaires. Fourth, we evaluated participants' responses (*n* = 971) to understand the structural model between their conceptions of and approaches to m-learning.

In this study, a PLS analysis, that is a new path analysis method, was used to verify the structural framework (W. W. Chin, Marcolin, & Newsted, 2003). This method can replace ordinary least squares regression or structural equation modelling. PLS differs from traditional path analysis methods insofar as it is capable of exploring complex cause–effect relationships and, as such, meets the goals of the study (Ringle, Sarstedt, & Straub, 2012). Specifically, this study utilized SmartPLS 2.0 to assess the structural model.

Finally, we conducted a latent profile analysis (LPA) to clarify Chinese undergraduate students' m-learning profiles. It is noted that LPA could lead to a greater understanding of the underlying subgroups of the phenomenon (Hagenaars & McCutcheon, 2002). We further performed the multivariate analyses of variance to evaluate the role of the m-learning profiles in approaches to m-learning.

3.6 | Reliability and validity analysis

CFAs were applied to test the composite reliability (CR), internal reliability, and convergent and discriminant validities of the two questionnaires. First, the internal consistency was determined by testing the CR of the constructs (Fornell & Larcker, 1981). According to Hair, Black, Babin, and Anderson (2009), the suggested threshold CR value is above 0.5. Second, a reliability analysis of the questionnaire was examined using Cronbach's alpha value to evaluate the consistency of the variables. Third, the convergent validity has been evaluated. The criteria are that the average variance extracted (AVE) values should be at least 0.5 (Fornell & Larcker, 1981) and that the factor loadings of all items should be above 0.7 (Nunnally, 1978). Fourth, the discriminant validity ascertains whether the constructs are independent of each other (Gefen & Straub, 2005).

4 | RESULTS

4.1 | Measurement model: CFA and its reliability and validity

The CFA further confirmed the reliability and validity among the structures of the conceptions of and approaches to m-learning instruments. Tables 5–7 summarize all of the factor loadings, AVE values, and Cronbach's alpha values of the 60 items for the 13 structures after removing items with a factor loading of less than 0.7. The fitness of the structure, factor loadings >0.7, and AVE > 0.5 indicated a

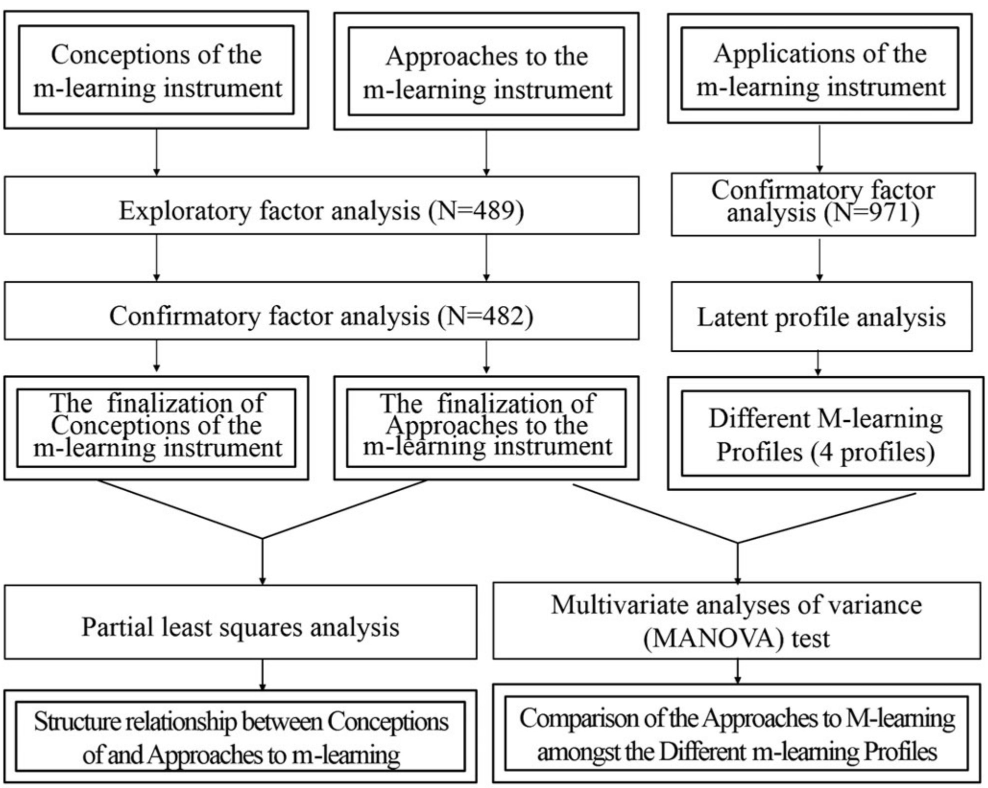

FIGURE 1 Outline of the research procedure

sufficient fit of the three instruments. The reliability (Cronbach's $\alpha > 0.7$) coefficients for the conceptions of, approaches to, and applications of m-learning instruments (Tables 5–7) suggest that these structures have a high reliability in assessing undergraduate students' beliefs towards the conceptions of, approaches to, and applications of m-learning. They also indicate a good convergent validity.

Table 8 presents the correlation matrix and the square root of the AVE values involving each construct. To validate the discriminant validity, Fornell and Larcker (1981) indicated that the square root of the AVE value, that is only one for each latent construct, should be greater than 0.5. Moreover, W. W. Chin (1998) emphasized that the square root of the AVE value by a construct should exceed the correlation coefficients between that construct and other structures. As shown in Table 8, the results of all constructs satisfied both criteria, thereby assuring the discriminant validity. Indeed, the structure of the overall questionnaire

TABLE 5 Factor loadings and the reliability of the conceptions of m-learning instruments

Construct	Factor loadings	*t*-value	Cronbach's *α*	Mean	*SD*
Assessment tools for testing (T)			0.88	4.42	0.85
T1	0.87	42.28***			
T2	0.85	40.55***			
T3	0.89	45.30***			
T4	0.83	43.33***			
Efficient tools for achieving a higher status (G)			0.84	3.84	0.68
G1	0.79	28.82***			
G2	0.78	27.47***			
G3	0.75	21.20***			
G4	0.86	29.44***			
G5	0.74	26.68***			
Application of extended ideas (A)			0.86	3.16	0.63
A1	0.80	36.89***			
A2	0.80	37.31***			
A3	0.86	35.81***			
A4	0.81	35.72***			
A5	0.73	26.54***			
Capture tools for memorization (M)			0.85	4.16	0.82
M1	0.84	38.75***			
M2	0.90	39.09***			
M3	0.90	47.57***			
Communication for enhancing understanding (U)			0.79	3.11	0.60
U1	0.81	30.05***			
U2	0.81	28.68***			
U3	0.73	21.48***			
U4	0.79	29.46***			
Focusing on continuous learning (C)			0.77	3.09	0.65
C1	0.85	21.79***			
C2	0.87	25.13***			
C3	0.77	18.01***			

***$p < 0.001$.

TABLE 6 Factor loadings and the reliability of the approaches to m-learning instruments

Construct	Factor loadings	*t*-value	Cronbach's *α*	Mean	*SD*
Surface motives (SM)			0.92	3.82	0.74
SM1	0.78	13.66***			
SM2	0.76	13.58***			
SM3	0.83	16.89***			
SM4	0.82	13.36***			
SM5	0.81	13.12***			
SM6	0.81	14.02***			
SM7	0.79	13.86***			
SM8	0.78	12.47***			
Surface strategies (SS)			0.85	4.03	0.68
SS1	0.78	12.84***			
SS2	0.77	13.74***			
SS3	0.81	13.23***			
SS4	0.74	10.58***			
SS5	0.73	10.00***			
SS6	0.74	10.78***			
Deep motives (DM)			0.87	3.75	0.58
DM1	0.77	15.87***			
DM2	0.78	17.47***			
DM3	0.82	18.32***			
DM4	0.73	13.38***			
DM5	0.77	13.92***			
DM6	0.76	17.35***			
Deep strategies (DS)			0.87	3.32	0.62
DS1	0.76	16.74***			
DS2	0.85	21.22***			
DS3	0.83	21.76***			
DS4	0.77	18.40***			
DS5	0.84	21.37***			

***$p < 0.001$.

TABLE 7 CFA analysis of the applications of m-learning instrument

Construct	Factor loading	*t*-value	Cronbach's *α*
Content-based (CB)			0.82
CB1	0.64	11.69***	
CB2	0.72	13.06***	
CB3	0.81	14.22***	
CB4	0.72	—	
Supportive (ST)			0.79
ST1	0.69	12.47***	
ST2	0.85	14.42***	
ST3	0.68	—	
Collaborative (CT)			0.88
CT1	0.85	22.10***	
CT2	0.82	20.63***	
CT3	0.87	—	

Note. CFA: confirmatory factor analysis.

***$p < 0.001$.

was verified now that the measures for the convergent and discriminant validity demonstrated an appropriate model fit.

The CFA models were used for further investigation. Table 9 shows the CRs and AVE values of the measures in the second-order models (CRs equal to or greater than 0.80 and AVE values greater than 0.5), which provided evidence of reliable measures of the three higher order structures. Moreover, as indicated by the results in Table 9, the loadings of the first-order latent variables on the second-order structures exceeded 0.80 (all loadings were significant at $p < 0.001$). The results confirmed the three-structure model, which included reproductive, transitional, and constructive conceptions of m-learning (Figure 2).

Tables 3 and 4 show the undergraduate students' average scores and standard deviations on the scales of conceptions of and approaches to m-learning survey, respectively. All students were above three on a 1- to 5-point Likert scale, implying that, in an m-learning environment, the mean values and standard deviations reported in this study are acceptable.

TABLE 9 Standardized CFA second-order coefficients

Second-order factor model	Loading value	*t*-value	CR
Reproductive			0.90
Capture tools for memorization	0.84	65.72***	
Assessment tools for testing	0.91	138.75***	
Transitional			0.86
Efficient tools for achieving a higher status	0.91	110.91***	
Focusing on continuous learning	0.69	21.11***	
Constructivist			0.91
Communication for enhancing understanding	0.90	106.64***	
Application of extended ideas	0.94	134.78***	

Note. CFA: confirmatory factor analysis; CR: composite reliability.
***$p < 0.001$.

4.2 | Correlation analysis

Table 6 shows the Pearson correlation analysis between the conceptions of m-learning and approaches to m-learning, which allows us to obtain a better understanding of their relationships. The results are as follows: (a) "assessment tools for testing" were negatively related to deep strategies ($p = 0.01$); (b) "capture tools for memorization" were not significantly related to "focusing on continuous learning" ($p = 0.06$); (c) surface strategies were negatively related to "communication for enhancing understanding" ($p = 0.01$), "application of extended ideas" ($p = 0.01$), and "focusing on continuous learning" ($p = 0.01$); and (d) constructive conceptions of m-learning were not significantly relevant to reproductive conceptions of m-learning ($p = 0.03$) and surface strategies ($p < 0.01$). The other structures were positively related to each other. According to Cohen's (1988) criterion for the effect size, the abovementioned correlation results revealed small effect size coefficients.

4.3 | Structural relationships between students' conceptions of and approaches to m-learning

A path model (Figure 3) was proposed to examine the relationships between the two factors mentioned above through the SmartPLS 2.0 program. The results showed that the model could approximately explain the data, and further studies to examine the model were recommended. All path coefficients were statistically significant.

In the model, the reproductive conceptions of m-learning positively predicted surface motives ($\beta = 0.45$), surface strategies ($\beta = 0.45$), and deep motives ($\beta = 0.19$). Moreover, constructivist conceptions of m-learning were positive predictors of deep motives ($\beta = 0.33$) and deep strategies ($\beta = 0.50$). Furthermore, transitional conceptions of m-learning seemed to slightly contribute to surface

TABLE 8 Correlation and discriminant validity of the conceptions of and approaches to m-learning

Factors	AVE	1	2	3	4	5	6	7	8	9	10	11	12	13
T	0.73	**0.85**												
G	0.60	0.43***	**0.77**											
A	0.63	−0.07*	0.41***	**0.79**										
M	0.75	0.54***	0.48***	0.10**	**0.87**									
U	0.61	−0.07*	0.37***	0.69***	0.12***	**0.78**								
C	0.70	−0.08*	0.32***	0.66***	0.06	0.65***	**0.84**							
SM	0.63	0.51***	0.40***	0.07*	0.39***	0.14***	0.09**	**0.79**						
SS	0.58	0.48***	0.34***	−0.01	0.40***	0.01	0.01	0.60***	**0.76**					
DM	0.57	0.19***	0.50***	0.47***	0.37***	0.49***	0.44***	0.30***	0.25***	**0.75**				
DS	0.65	0.01	0.38**	0.54**	0.21**	0.61**	0.52**	0.23**	0.09**	0.60**	**0.81**			
Reproductive	0.58	–	–	–	–	–	–	0.51***	0.50***	0.32***	0.12***	**0.76**		
Transitional	0.51	–	–	–	–	–	–	0.31***	0.22***	0.58***	0.55***	0.32***	**0.71**	
Constructivist	0.53	–	–	–	–	–	–	0.11***	0.00	0.52***	0.63***	0.03	0.70***	**0.72**

Note. AVE: average variance extracted; T: m-learning as assessment tools for testing; G: m-learning as efficient tools for achieving a higher status; A: m-learning as application of extended ideas; M: m-learning as capture tools for memorization; U: m-learning as communication for enhancing understanding; C: m-learning as focusing on continuous learning; SM: surface motives; SS: surface strategies; DM: deep motives; DS: deep strategies. The square root of the AVE value is in bold on the diagonals. Off diagonals are the Pearson correlations of the constructs.

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

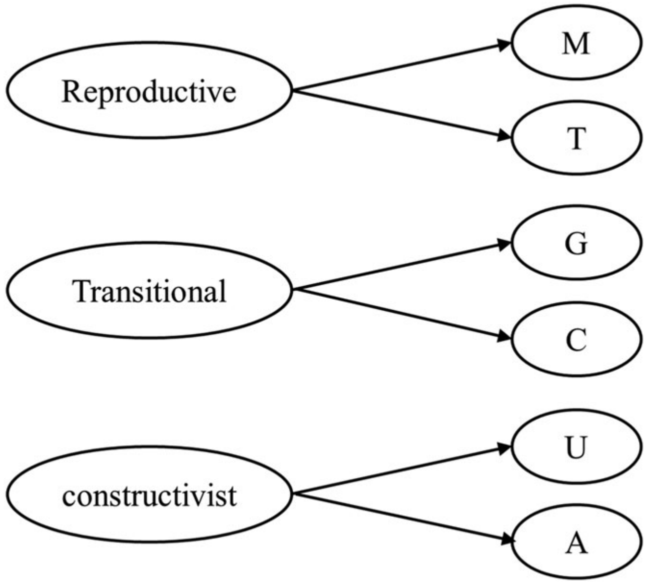

FIGURE 2 Second-order CFA of the conceptions of m-learning. T: m-learning as assessment tools for testing; M: m-learning as capture tools for memorization; G: m-learning as efficient tools for achieving a higher status; C: m-learning as focusing on continuous learning; U: m-learning as communication for enhancing understanding; A: m-learning as application of extended ideas; CFA: confirmatory factor analysis

motives (β = 0.18) and surface strategies (β = 0.16). In addition, deep motives (β = 0.29) and deep strategies (β = 0.20) were predicted by transitional conceptions of m-learning to some extent.

The path analysis results indicated that students, who believe that m-learning was primarily about using assessment tools for testing or capture tools for memorization, tended to use reproductive means to learn in an m-learning environment, such as utilizing mobile phones to capture important knowledge for an examination. Meanwhile, students who regarded m-learning as the application of extended ideas or communication for enhancing understanding were more oriented towards emphasizing the meaningful construction of knowledge in an m-learning environment.

Particularly, the results revealed that students who agreed m-learning was focused on continuous learning and was an efficient tool for achieving a higher status appeared to display surface approaches (e.g., repeating and memorization for high scores). Meanwhile, this group of students seemed to also possess deep approaches (e.g., strong initiative and application of creative ideas) in the m-learning settings.

4.4 | Latent profile analysis for m-learning profiles

The results of LPA and each profile's number of participants are listed in Table 10. The Akaike's information criterion, Bayesian information criterion, and adjusted Bayesian information criterion values appeared in descending order as the number of profiles increased from one to four, indicating the four-profile solution merits further exploration with well-separated profiles emphasizing (Entropy = 0.92; Celeux & Soromenho, 1996).

Table 11 presents the mean values of content-based, supportive, and collaborative applications in these variables, and the multivariate analysis of variance results with the least significant difference post hoc tests. First, the results showed a significant effect for the m-learning profiles (Wilks' λ = 0.12, F = 161.92, p < 0.001). Additionally, significant difference among the four

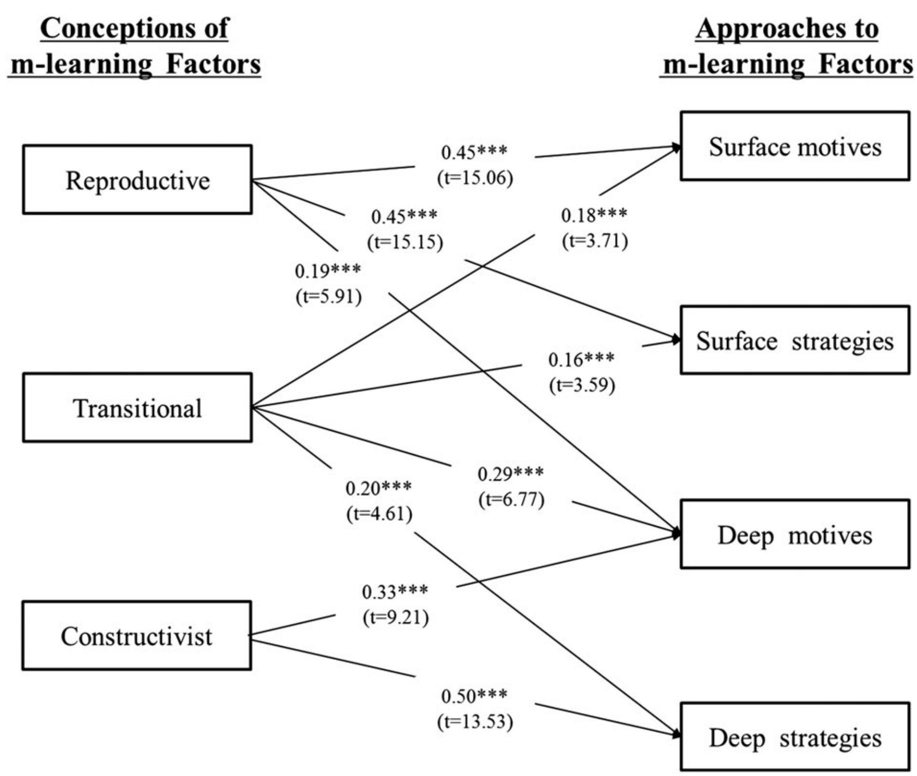

FIGURE 3 Path analysis and path coefficients of the conceptions of and approaches to m-learning. $^{***}p$ < 0.001

TABLE 10 The fit indices and the numbers of participants in each profile

Number of Profiles	AIC index	BIC index	Entropy	LMRT
1	78,160.85	78,473.06		
2	72,898.59	73,371.79	0.92	5,304.89***
3	70,616.03	71,250.21	0.94	2,338.26**
4	69,241.80	70,036.97	0.92	1,433.91*

Note. AIC: Akaike's information criterion; BIC: Bayesian information criterion; LMRT: Lo–Mendell–Rubin test.

*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

profiles was found based on the least significant difference post hoc tests (see Table 11). Accordingly, we defined the profiles in terms of their distinctive characteristics of those applications, namely, content-based, supportive, and collaborative.

As listed in Table 11, a total of 136 participants were assigned to profile 4. These participants attained the highest mean values for all three applications compared to the other profiles. Thus, we defined profile 4 as the "high-engagement learning" profile. As the participants in profile 3 ($N = 471$) achieved relatively higher values for all applications, we defined this profile as the "mixed learning" profile. Profile 2 consisted of 210 participants who had average mean values for both content-based and supportive applications. This means that the students in this group consider the medium used for learning to be within the broad spectrum of m-learning, encompassing numerous tools including email, Internet, and instant messaging apps, and social networks like SMS, WhatsApp, WeChat, and Twitter. These students regarded the curriculum mobile apps as a delivery platform for issuing notices, assigning homework, and displaying syllabi and video cases, or as a mobile tool to supplement traditional learning. Thus, profile 2 was defined as the "surface-supportive learning" profile. A total of 154 participants were classified as profile 1. The participants in profile 1 showed the least meaningful gains for all applications, and thus, profile 1 was defined as the "passive learning" profile.

TABLE 11 The profiles of the participants' critical applications of m-learning

		N	Mean	*SD*	*F* (ANOVA)	Post hoc test (LSD)
Content-based	1	154	2.10	0.60		4 > 3 > 2 > 1
	2	210	2.53	0.58		
	3	471	2.71	0.49		
	4	136	3.23	0.69		
	Total				103.59***	
Supportive	1	154	1.90	0.44		3 > 1
	2	210	1.87	0.51		4 > 1
	3	471	2.50	0.48		3 > 2
	4	136	2.45	0.75		4 > 2
	Total				90.31***	
Collaborative	1	154	1.82	0.44		3 > 1
	2	210	1.88	0.51		4 > 1
	3	471	2.43	0.48		3 > 2
	4	136	2.50	0.75		4 > 2
	Total				97.22***	

Note. 1 = passive; 2 = surface-supportive; 3 = mixed; 4 = high-engagement. ANOVA: analysis of variance; LSD: Fisher's least significant difference tests.

***$p < 0.001$.

4.5 | Comparison of the approaches to m-learning among the different m-learning profiles

Table 12 lists the multivariate analysis of variance results of the participants' approaches to m-learning for comparing the four profiles. Significant differences were discerned among the approaches to m-learning of the four m-learning profiles (Wilks' $\lambda = 0.85$, $F = 6.87$, $p < 0.001$). Additionally, the results indicated significant interactions among the four dimensions of approaches to m-learning for the m-learning profiles (deep motives: $F = 315.76$, $p < 0.001$; deep strategies: $F = 212.35$, $p < 0.001$; surface motives: $F = 547.89$, $p < 0.001$; and surface strategies: $F = 401.59$, $p < 0.001$).

In terms of deep motives, the participants in the high-engagement learning profile realized higher mean values in comparison with those in the passive, surface supportive, and mixed profiles. Furthermore, the surface-supportive learning profile participants scored lower than those in the mixed profile. Regarding deep strategies, the participants in the high-engagement learning profile performed significantly better than those in the passive learning and surface-supportive learning profiles. The participants in mixed learning profile also demonstrated significant gains over those in passive and surface-supportive ones.

For surface strategies, the participants in the high-engagement learning profile again achieved superior outcomes compared to those in all other profiles. Interestingly, the surface-supportive profile participants performed comparatively better than did those in the mixed and passive learning profiles.

Finally, regarding the dimension of surface strategies, participants in the high-engagement learning profile realized the highest mean values compared to all other profiles. Again, the participants in the

TABLE 12 The comparisons of approaches to m-learning among the different profiles

		N	Mean	*SD*	*F* (ANOVA)	Post hoc test (LSD)
Deep motives	1	154	2.01	0.41		4 > 3 > 2 > 1
	2	210	2.33	0.41		
	3	471	2.88	0.35		
	4	136	3.20	0.53		
	Total				315.76***	
Deep strategies	1	154	1.84	0.44		4 > 1
	2	210	1.83	0.44		3 > 1
	3	471	2.61	0.45		4 > 2
	4	136	2.82	0.74		3 > 2
	Total				212.35***	
Surface motives	1	154	1.91	0.37		4 > 2 > 3 > 1
	2	210	2.86	0.51		
	3	471	2.51	0.36		
	4	136	3.80	0.48		
	Total				547.89***	
Surface strategies	1	154	2.31	0.51		
	2	210	3.61	0.50		4 > 2 > 3 > 1
	3	471	3.02	0.40		
	4	136	4.03	0.58		
	Total				401.59***	

Note. 1 = passive; 2 = surface-supportive; 3 = mixed; 4 = high-engagement. ANOVA: analysis of variance; LSD: Fisher's least significant difference tests.

***$p < 0.001$.

surface-supportive learning profile outperformed those in the mixed learning profile in mean values.

5 | DISCUSSION

5.1 | Undergraduate students' conceptions of m-learning

The aim of this study was to explore undergraduate students' conceptions of m-learning through a survey analysis. The six conceptions of m-learning suggested that students' conceptions of m-learning are a hierarchical system that ranges from reproductive conceptions to constructivist conceptions, which was revealed by many studies (T. C. Lin, Liang, & Tsai, 2015a; H. M. Lin & Tsai, 2008; H. M. Lin & Tsai, 2011).

Nevertheless, the analysis of students' conceptions of m-learning is limited by regional and cultural differences. The proposed reproductive and constructive perspectives could not explain some students' behaviours, specifically when they actively engaged themselves in learning using mobile devices in a meaningful way, because of long-term traditional education. Hence, a new category of "focusing on continuous learning" was added herein to better illustrate the transitional period of conceptions of m-learning from reproductive to constructive conceptions. This category stresses undergraduate students' continued use of mobile devices to meet learning demands (e.g., awareness of initiative and autonomy in terms of contacting their teachers when needed). Another category that was considered as a transitional conception of m-learning was "efficient tools for achieving higher status." Teachers usually upload successful or outstanding cases to the m-learning platform in an effort to encourage students; hence, many undergraduate students attend m-learning classes for opportunistic reasons, such as better jobs. The interpretation of this kind of behaviours could not be categorized into either reproductive or constructivist conceptions of m-learning. Thus, transitional conceptions of m-learning clearly consisted of "focusing on continuous learning" and "achieving a higher status."

Overall, this study classified conceptions as reproductive, transitional, and constructive, which were consistent with the results in the study of T. J. Lin et al. (2015b) that characterized the conceptions of learning physics into three levels based on a cluster analysis. Given that transitional conceptions of m-learning play an intervening role between reproductive and constructivist conceptions, educators should promote students' m-learning conceptions of focusing on continuous learning and achieving a higher status. This would be an important step to nurture higher order conceptions of m-learning.

5.2 | Path analysis between students' conceptions of and approaches to m-learning

This study further investigated how learners' conceptions of m-learning affect their approaches to m-learning. The findings of this study revealed that students' perceptions of m-learning are associated with their approaches to m-learning.

First, the reproductive conceptions of m-learning were significantly related to the surface approaches to m-learning, most notably to deep motives. The results were in agreement with many studies to some extent (e.g., Chiou et al., 2012; Lee et al., 2008). Lee, Lin, and Tsai (2013) explicitly indicated that reproductive learning conceptions positively predicted surface learning approaches. Remarkably, reproductive conceptions could have an influence on deep motives in addition to surface approaches. In light of these findings, the introduction of mobile technology can bring about new teaching practices that raise students' learning interests, such as the use of mobile applications for memorizing and passing examinations. Accordingly, as the Chinese educational reform emphasizes constructivist pedagogical approaches, students might have ambitions to acquire and apply in-depth knowledge. However, they might not know how to adopt deep strategies.

Second, the constructive conceptions of m-learning were positively associated with the deep approaches to m-learning. The results seemed congruent with the findings of Lee, Johanson, and Tsai (2008), which confirmed that higher level conceptions of learning might contribute to deep approaches. The findings proved that students who view m-learning as constructive learning may possess deep motivations and deep strategies in an m-learning environment. Simply taking m-learning as a communication tool (e.g., just expressing ideas) and an application tool (e.g., capturing photos), the extent of these conceptions is more than enough to enhance, understand, and extend ideas. For instance, students with higher level conceptions of online argumentation may adopt deep approaches, such as evaluating posts containing challenging ideas and making careful reflections (C. C. Tsai & Tsai, 2013). Therefore, researchers and educators should highlight communication features for enhancing, understanding, and applying extended ideas for m-learning practices.

Third and most interestingly, the transitional conceptions of m-learning positively predicted the surface approaches to m-learning and indicated a greater likelihood that deep approaches to m-learning were adopted. The findings inspire some potential solutions for the cyberspace "separation" between teachers and students. For those motivated students who want to achieve a higher status, university teachers should give enough freedom while designing instructional content for self-paced learning and designing instructional software and content (e.g., Liu, Lin, Tsai, & Paas, 2012). At this time, the mobile platform serves as an efficient tool that records and analyses the pace of learning to help students develop their own learning problems.

Additionally, timely and on-demand services should be provided according to teachers' schedules. During m-learning, students have many doubts and difficulties but might not consult their teachers, because they are busy with other courses and association activities. Thus, teachers must provide timely and on-demand support services (e.g., online synchronous video interaction and location-based and situation-aware learning resources) to guide students in continuous learning. In the case of a synchronous cyber classroom (Chao, Hung, & Chen, 2012), teachers adopted a Collaborative Cyber Community (3C) platform for synchronous instruction (e.g., instant text communication and online synchronous assessment). In this way, students could lead self-directed learning online at different physical locations. This case demonstrates that m-learning acts as an efficient tool for achieving a higher status; online technology makes learning more efficient without the restrictions of time and space, enabling students to progress at their own space to achieve a higher status. This case also demonstrates m-learning as focusing on continuous learning such that students can continuously learn as they obtain timely learning assistance and realize fine-tuning adjustments according to the revisions and feedback given by the system.

That synchronous cyber classrooms make up for the absence of involvement in traditional online learning environments (e.g., web browsing) and utilize systematic recording and analysis to prevent students from dropping out when they face learning difficulties are of great significance. Just as Shadiev, Hwang, Huang, and Liu (2018) demonstrated, a tight collaboration with an m-learning system characterized by synchronous and face-to-face forms might help avoid misunderstandings and clarify some important points with explicit explanation. When students learn individually or asynchronously, they could not obtain peer feedback instantly such that they would feel lack of a sense of presence.

However, these influence coefficients are not as good as those of the reproductive and constructivist conceptions of m-learning. This finding may be explained by the educational environment and cultural background in China. On the one hand, although current Chinese educational reform emphasizes student-centred and activity-based instructional approaches, examination-oriented teaching at school and national levels remains important when assessing student performance (Lee et al., 2008). Thus, students with transitional conceptions of m-learning (i.e., focusing on continuous learning and achieving a higher status) may fear that they will fail in the examinations, consequently adopting surface strategies for m-learning (e.g., capturing for memorization). The cultural context mentioned earlier was discussed by Chiou et al. (2012).

On the other hand, the pressure from teachers and parents to do well in exams may impose a very heavy burden on this group of students, which is not beneficial to their development of deep approaches. For instance, students simply utilized their mobile devices (cell phones, mobile phones, social media, etc.) to acquire information to complete tasks assigned by teachers (Gikas & Grant, 2013). This reflects the fact that teachers get used to utilizing goal-orientated pedagogical methods that focus on how to attain a certain grade rather than achieving a greater understanding (e.g., deeper reflection, migration and application of knowledge, and problem solving). For these reasons, transitional conceptions are not the predictors of deep approaches as much as constructive conceptions. From the abovementioned points, it is easy to understand why teaching approaches assisted by mobile technology cannot promote the long-term benefits of teaching even though more time and energy are spent. Therefore, reproductive, transitional, and constructive conceptions of m-learning should be valued by teachers to help students acquire surface and deep approaches.

5.3 | Roles on approaches to m-learning among different m-learning profiles

The surface supportive profile proved particularly interesting. Surface supportive students are not keen on passive learning; however, they also fail to engage with learner-centred m-learning programs. By recognizing and acknowledging student learning profiles, teacher can deepen student perceptions of m-learning. More learner-centred learning activities could be conducted to underscore the importance of improved learner-centred authority as assisted by mobile technology. Substantial work should focus on the surface-supportive profile, which includes applying deep-motive strategies to engage in m-learning activities and the use of social network services to facilitate collaboration (Lin, Hu, Hu, & Liu, 2016).

Another promising finding in the understanding of the m-learning application status is that most students have surface-supportive and mixed m-learning profiles. However, the dividing line might not lie between surface and deep mobile-assisted learning, rather it may distinguish between technology-assisted learning and learner-centred learning. Meanwhile, identical points are obtained in technology application, where smartphones are considered assistant tools. Undergraduate students with the surface-supportive profile might not expect to acquire systematic and professional course learning resources strictly through mobile media. Instead, they utilize these diversified resources to supplement their learning and address limited classroom time. This group of students regard mobile applications as delivery platforms that supplement traditional learning. They prefer to ask for help via email, SMS, and WhatsApp rather than sharing ideas with their peers. However, for the mixed profile, a multidirectional communication as occur through among social network applications can facilitate collective efforts to produce creative works. The students in a project group discuss the project content and supervise the project progress until completion.

The specific delivery platform exert a meaningful and differentiated influence on how students study. For instance, a moderator might post a draft on Twitter and Facebook that provides the time and rules for a subsequent online discussion. The students make comments to share and express their ideas, and the draft would be revised accordingly. After several rounds of discussion and collaboration, an improved version of the manuscript is regarded as the students' collaborative achievement. Notably, Facebook collaboration was effective role in linking friends with acquaintances, whereas Twitter collaborative networks reflected the influence of more strangers or potential friends. The trust relationship among members is crucial to deep interaction. Hence, teachers must actively guide students in systematic m-learning to realize a more meaningful construction.

Students with high engagement learning profiles tended to adopt both surface and deep approaches. The high engagement students were active participants in m-learning activities and also performed well in collaboration, producing high-quality work. This understanding of m-learning profiles tied well with the PLS analysis result, wherein transitional conceptions of m-learning at an alternate level between reproductive and constructivist perspectives affected on both surface and deep approaches. Thus, aside from regional and cultural elements, this latent profile analysis of m-learning application proved the significance of transitional conception presence.

6 | CONCLUSION

Identical conclusions were obtained in this study whereby there was a transitional process found while moving from reproductive to constructivist conceptions of m-learning. Besides, learning profiles were beneficial for explaining and demonstrating why students with transitional conceptions tended to take both surface and deep approaches.

Because these findings complement each other, the compatibility of those provides implications for both research and practice. For researchers, this study has taken a step in the directions of defining the relationship between undergraduate students' perspectives of m-learning (conceptions and learning profiles) and approaches to m-learning. In practice, college teachers should foster more sophisticated conceptions of m-learning among their students with the aim of expanding their learning profiles and approaches. Additionally, some epistemic development programmes must be well designed for the group of students with transitional conceptions of m-learning due to their high-engagement learning profile.

However, two limitations should be mentioned. First, students' conceptions of m-learning could be largely inferred to have a similar contribution to make, irrespective of different hardware configurations. Further research explicitly testifies to the inference by differentiating between m-learning hardware, such as smartphones, tablets, and laptops. Another limitation is that this study was not conducted in a domain-specific context or situation such as context-aware u-learning or problem-based collaborative learning. Participants' perceptions may vary when they carry out domain-specific tasks in u-learning environments. Thus, further studies should involve other conceptions of learning to attain a deeper the understanding of this issue. Cross-domain contextual and situational comparisons might provide more insightful findings. Furthermore, intervention studies warrant substantial attention to realize an epistemic evaluation of the conceptions of and approaches to m-learning.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest. The undergraduate students participated in this study responded to the survey voluntarily. Prior to starting any work, they read the cover statement that clarified the voluntary and anonymous nature for their responses and the right to withdraw. All participants in the study consented to their data being used for the purposes of this study.

ORCID

Xiao-Fan Lin http://orcid.org/0000-0002-4544-0849

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APPENDIX A

THE ITEMS OF THE SURVEY

TABLE A1 The conceptions of m-learning survey

Capture tools for memorization (M)
1. m-learning means to help me remember the important contents of the textbook via mobile devices (e.g., playback and repeatedly watching).
2. m-learning is to help me memorize some proper nouns in teaching materials via mobile devices.
3. m-learning is to help me remember what the teacher said in class via mobile devices.
Assessment tools for testing (T)
4. m-learning can improve my learning competencies.
5. As for as I am concerned, m-learning is mainly to get a better job.
6. m-learning enables me to get more useful learning materials and information.
7. m-learning can improve my learning efficiency.
Efficient tools for achieving a higher status (G)
8. For the purpose of career planning, I learn in an m-learning environment.
9. m-learning is mainly to acquire knowledge or skills so as to help me solve problems in real life.
10. m-learning helps me get information and solve my questions.
11. m-learning help me learn more relevant knowledge and improve professional literacy.
12. m-learning not only helps me get more information or media (video, animation, audio, text, etc.), but also helps me better understand the domain and knowledge that I am interested in.
Application of extended ideas (A)
13. m-learning can help me apply what I have learned to different fields.
14. m-learning is to achieve high marks in examinations. (e.g., using mobile devices to do exercises and get instant scores and evaluation).
15. As far as I am concerned, m-learning is to get certificates.
16. For the purpose of the examination, I learn in an m-learning environment.
17. There is a closed relationship between learning and examination in an m-learning environment.
Communication for enhancing understanding (U)
18. When discussing and communicating via mobile devices, I can deepen my understanding of the professional knowledge.
19. When discussing and communicating via mobile devices, I can understand more professional situations and knowledge.
20. When discussing and communicating via mobile devices, I can better understand what teachers said.
21. When discussing and communicating via mobile devices, I can have more topics with my classmates.
Focusing on continuous learning (C)
22. By m-learning, I can approach a problem form more than one perspective.
23. By m-learning, I can form a new perspective on professional knowledge.
24. By m-learning, I can keep learning, whether we are in different times, seasons, locations, or not.

Note: The questionnaire was adapted from the web-based conceptions of learning management questionnaire (H. M. Lin & Tsai, 2011) and the conceptions of ubiquitous learning questionnaire (P. S. Tsai, Tsai, & Hwang, 2011a).

TABLE A2 The approaches to m-learning survey

Deep motives (DM)
1. I always feel satisfied in an m-learning environment.
2. In an m-learning environment, when I started learning, I always find the contents interesting.
3. M-learning is very interesting, so I always work hard and study seriously.
4. I always look forward to learning using mobile devices.
5. During m-learning, I often think about problems raised by teachers and students in my spare time.
6. In an m-learning environment, I can always form relevant perspectives or conclusions about what I have learnt.
Deep strategies (DS)
7. I will start my m-learning with questions, hoping to get answers in the course.
8. In an m-learning environment, I would like to apply new knowledge to reality.
9. During m-learning, I try to find out the relationship between the course contents and what I have learned before.
10. In an m-learning environment, I will integrate new knowledge into what I have learnt.
11. In an m-learning environment, I will try my best to understand the meaning of related concepts.

(Continues)

TABLE A2 (Continued)

Surface motives (SM)
12. I will be disappointed when I can't get the high score in m-learning courses.
13. I will feel disappointed if I cannot get approvals in an m-learning course.
14. In an m-learning environment, even though I try very hard to prepare for the course examinations, I am still worried that I cannot get good grades.
15. Though I work hard for preparing m-learning tests, I am still worried about not receiving approvals.
16. In an m-learning environment, I feel worried if my learning performance is not up to my teachers' expectations.
17. I am worried that my performance in m-learning courses is not good enough to get approvals.
18. I am eager to get good grades, so I always study seriously in an m-learning environment.
19. I always study seriously in order to get teachers' praise.
Surface strategies (SS)
20. When I think that I can get good grades, I will devote little time to m-learning.
21. As far as I am concerned, the best way to get teachers' praise is to memorize the answers as possible as I can.
22. In an m-learning environment, I think it is unnecessary to spend time on each knowledge point, because I also need to prepare for other subjects or exams (reverse).
23. I will learn the course emphases according to teachers' requirements, because it is unnecessary to spend time on other parts of m-learning courses.
24. In an m-learning environment, the best way to get good grades is to memorize the answers as possible as I can.
25. I learn based on course emphases, because there is no need to devote much time to m-learning.

Note: The questionnaire originated from Yang and Tsai (2010).

TABLE A3 The applications of m-learning survey

Content-based
1. I often acquire knowledge through mobile devices.
2. I often search for learning materials online, and m-learning has changed the way I get learning materials.
3. I usually use mobile learning applications to record and analyse wrong topics or learning problems.
4. I use your mobile device to listen to course videos or recordings.
5. I often think about problems raised by teachers and students in the mobile learning environment during my free time.
Supportive
6. I always form relevant insights or conclusions about the learning domains I have learned in m-learning environments.
7. I easily ask for help via SMS, email, or social networking applications, such as Twitter, WhatsApp, WeChat, QQ, and Facebook, in m-learning environments.
8. I often browse others learning cyberspace via social networking applications, such as Twitter, WhatsApp, WeChat, QQ, and Facebook, in m-learning environment.
9. In order to master a learning skill (e.g., improve my English listening), I use the m-learning applications.
10. I often comment on others' cyberspace information (articles, pictures, videos, and audios) in m-learning environments.
11. I provide help online (via SMS, email, or social networking applications, etc.) to help my partners.
Collaborative
12. I exchange learning information in a group via SMS, email, or social networking applications, such as Twitter, WhatsApp, WeChat, QQ, and Facebook.
13. I often use mobile devices to collaborate with other learners, teachers, and experts.
14. I often carry out ongoing project work with my team in m-learning.
15. The m-learning applications help me better get the support and help that I learned from the collaborative project.
16. In the process of discussion with teachers and classmates using mobile applications, I feel that my level of thinking has improved.
17. Collaborative data gathering in mobile applications is of great help for a team in promoting the collaborative work.

Note: The questionnaire was modified from Deegan and Rothwell's (2010) study.