Configuring complex and dynamic determinants of undergraduate students' continuous usage of learning management system mobile apps: Insights from fsQCA

Xi Fang
Zhejiang Gongshang University, China
https://orcid.org/0000-0002-8736-1700

Liangjjie Zhu
Zhejiang Gongshang University, China
https://orcid.org/0000-0003-2516-7694

Shuang Xin
Zhejiang Gongshang University, China
https://orcid.org/0009-0000-7403-974X

Research lacks a comprehensive analysis of the factors influencing students' continuous usage of learning management system (LMS) mobile applications, especially considering the heterogeneity and dynamic psychological changes among undergraduate students. This study employed an integrative stimulus-organism-response model and complexity theory for exploring the complex and dynamic processes that lead to students' continuous usage intentions, based on their perceptions of app quality attributes and emotional responses. Using fuzzy-set qualitative comparative analysis on survey data collected from 400 undergraduate students in China, this study identified six distinct configurations that encompassed various combinations of app quality attributes and emotional responses, which may contribute to students' intention to continue using LMS apps. The findings highlight the complex and dynamic nature of students' reactions to LMS apps in the context of higher education. It offers significant implications for higher education educators, enabling them to better understand their students and enhance students' intentions to continuously use LMS apps in their learning activities.

Implications for practice or policy:

- LMS operators should comprehensively address both app quality attributes and students' affective responses to increase students' continuous usage intentions.
- Instructors should endeavour to elicit students' affective responses to LMS applications through various integrated course activities.
- Instructors should focus on improving their attitudes, increasing student interactions and encouraging students' feelings of autonomy.

Keywords: learning management system applications (LMS apps), perceived quality attribute, post-usage affections, students' continuous usage intentions, fuzzy-set qualitative comparative analysis (fsQCA), undergraduate students

Introduction

Mobile technologies, as one representative type of digital technologies, have been integrated into higher education as a crucial paradigm shift, offering substantial benefits to stakeholders in the learning ecosystem. These technologies have demonstrated their efficacy in bridging communication gaps between teacher-student and student-student (Sánchez-Prieto et al., 2019), facilitating remote collaboration (Eraslan & Kutlu, 2019) and enabling personalised feedback beyond traditional classroom boundaries (Nikou & Economides, 2019). Consequently, higher education institutions are increasingly advocating for the incorporation of mobile technologies in pedagogical practices.

A pivotal manifestation of this technological integration is the widespread adoption of learning management system (LMS) mobile applications. Unlike general mobile apps, LMS apps serve specific pedagogical functions: facilitating knowledge acquisition, enabling personalised feedback and learning experiences, supporting collaborative learning and diverse learning preferences and improving academic outcomes through enhanced engagement (Almusharraf, 2024; Altawalbeh, 2023). These apps, designed to facilitate various learning tasks such as information access and attendance tracking (Pollara, 2011), incorporate diverse functional and experiential quality attributes that positively influence students' learning processes (Dashti & Aldashti, 2015). By utilising smartphone applications, students can achieve a deeper understanding of the learning content and enhance their engagement (Lopez et al., 2014). However, integration of mobile technology in higher education presents several challenges, including low usage levels, limited utilisation (e.g., content delivery only), and a failure to meet students' expectations (Margaryan et al., 2011).

Furthermore, the education sector faces a significant challenge in fostering consistent and sustained use of LMS apps among students. Not all students readily embraced these apps, with usage often driven by course requirements rather than voluntary adoption (Dashti & Aldashti, 2015). LMS app usage in higher education is institutionally mandated – students are required to use these apps for quizzes, tests, assignment submissions and access to course materials (Kim & Park, 2023; Soko et al., 2024). Unlike voluntary consumer apps, continuous usage intention in educational contexts reflects students' recognition of LMS utility for achieving learning goals, with engagement driven by pedagogical relevance and usability (Almusharraf, 2024). This intention develops within institutionally mandated environments where sustained usage depends on overcoming the challenges of compulsory adoption (Altawalbeh, 2023). Importantly, such mandated adoption can trigger innovation resistance and inertia, which negatively impact sustained use intention (Kim & Park, 2023). Some students express ambivalence regarding their intentions to continue using LMS apps, potentially due to factors such as interface limitations or the absence of face-to-face interaction (Ren et al., 2022). Additionally, the multifunctional nature of mobile devices may present potential distractions, further complicating sustained engagement with educational apps (Alzahrani & Seth, 2021). The aforementioned diverse and complex student responses underscore the need for a comprehensive understanding of the factors influencing students' continued usage intentions of LMS apps.

This study adopted Jacoby's (2002) integrative stimulus-organism-response (S-O-R) model and Ragin's (2008) fuzzy-set qualitative comparative analysis (fsQCA) grounded in complexity theory (Woodside, 2013, 2014) to examine the complex configurations of factors that contribute to students' intentions to continue using LMS apps. Collectively, the aim was to capture the individual differences, asymmetries and diversities that underlie students' decisions regarding the sustained usage of LMS apps in higher education. This study explored the configurations of possible causal conditions from stimulus (perceived quality attributes of LMS apps) and organism (students' affective expressions), which represent different pathways leading to high-level students' continuous usage intentions of the LMS apps (response).

Literature review

LMS apps in higher education

LMSs have become integral to modern educational environments, yet the specific study of LMS mobile apps remains crucial due to their unique capabilities. While traditional LMS platforms offer a range of web-based learning management services (Hernández-García et al., 2024), LMS apps are specialised software designed for smartphones and tablets, integrating these functionalities into mobile devices (Ssekakubo et al., 2013). LMS platforms provide students with convenient access to learning materials, facilitate assignment submissions, enable effective communication and collaboration with instructors and peers and allow for the monitoring of academic progress. The ubiquity of mobile devices in students' lives further amplifies the importance of these apps in shaping the modern learning landscape (S. Kumar et al., 2021). Moreover, the unique user interface and experience design of mobile apps may significantly

influence student engagement, motivation and learning outcomes in ways that differ from traditional LMS platforms (Aljohani et al., 2019).

Despite these critical differences, much of the literature has tended to discuss LMS apps within the broader context of LMS technologies (Hernández-García et al., 2024), often not fully addressing their unique characteristics and impacts on students' reactions. As education increasingly embraces mobile technologies, a focused examination of students' specific reactions to LMS app usage in their learning activities becomes essential for comprehensively understanding and optimising technology-enhanced learning in the mobile era.

Students' reactions to LMS apps

Perceived quality attributes of LMS apps

Historically, the adoption of LMS mobile apps has been hindered by quality issues. Ssekakubo et al. (2013) reported that inadequate app quality led to low adoption rates among students for accessing LMS services via mobile devices. Ren et al. (2022) revealed that students continue to prioritise functional and experiential aspects in their evaluations of these apps. Furthermore, Dağhan and Akkoyunlu (2016) emphasised that individual learning styles and preferences significantly influence students' perceptions of online learning platform quality. Consequently, the perceived quality attributes of LMS mobile apps have emerged as crucial determinants of students' retention.

System interactivity emerges as a universally acknowledged quality attribute in both educational and commercial contexts (Cheng, 2012; Pappas et al., 2016). It refers to the perceived ability of the system to allow interactions between students and instructors (Sánchez-Prieto et al., 2019). Pappas et al. (2016) underscored the strong correlation between perceived interactivity and overall satisfaction with e-learning platforms. Interactivity, encompassing real-time feedback, personalisation and engagement mechanisms are crucial for fostering a sense of immersion and control in the learning or user experience (Bervell & Umar, 2020). Thus, designing LMS apps with robust interactivity features is imperative to meet students' expectations and enhance their perception of quality.

Another theme is the pivotal role of instructor attitude in shaping students' perceptions of e-learning systems (Cheng, 2012). Xu and Mahenthiran (2016) have highlighted the importance of instructors' enthusiasm, supportiveness and proficiency in utilising the technology, which significantly enhance users' perceptions of the system's user-friendliness and overall quality. However, the literature on educational LMSs has tended to focus more on instructor-mediated factors, underscoring the need for educators to be actively engaged and trained in leveraging technology to foster positive learning experiences (Bervell & Umar, 2020).

The functionality of an e-learning system directly impacts its perceived quality and usability (Xu & Mahenthiran, 2016). It is crucial for LMSs to offer a broad range of functionalities tailored to teaching and learning needs, such as content management, assessment tools and communication channels (Cheng, 2012). App evaluations have prioritised functionality as a cornerstone of quality, emphasising ease of use, reliability and feature richness (Pappas et al., 2016). By integrating robust and intuitive functionalities, LMS apps can better serve the diverse needs of educators and learners, thereby enhancing their overall satisfaction and perceived quality (Bervell & Umar, 2020).

Additionally, design quality is deemed a key functional component of e-system quality since mobile systems are competing largely for user attraction, which is influenced by the aesthetic design (Ha & Im, 2012). Design quality is usually represented by aesthetic design, which is defined as the colour, font types, background patterns, shapes and other visual attributes of a system (Hsieh et al., 2021). Therefore, aesthetics may significantly influence user engagement, satisfaction and, ultimately, the perceived quality of an app.

Considering the importance of both functional and experiential aspects in determining the quality of LMS apps, this study suggests aesthetic design and system functionality as functional aspects of LMS app quality attributes, instructor attitude and system interactivity as the experiential aspects of LMS app quality attributes.

Affective expression in response to LMS app usage

Affective expressions are considered the most extensively used factors representing users' internal reactions invoked by mobile apps (Goi et al., 2018). The dominant affective expression discussed is the arousal-pleasure-dominance sequence (D. S. Kumar et al., 2018). Arousal refers to the degree of sensory stimulation, energy, alertness, happiness or excitement in reacting to a stimulus (S. Kumar et al., 2021). Pleasure is defined as the state or feeling of happiness, satisfaction and enjoyment resulting from an experience that one finds enjoyable. Dominance reflects individuals' feelings of being able to control situations (Anwar et al., 2023). This tripartite sequence encompasses distinct emotional states that characterise user experiences with digital interfaces.

Integrating dominance and arousal as students' affective expressions towards the LMS app usage provides deeper insight into the affective mechanisms when explaining their reactions. However, LMS apps are different from commercial apps since students often begin using them due to instructors' requirements (Bervell & Umar, 2020). Consequently, this study proposes a modified framework that emphasises arousal and dominance while de-emphasising pleasure in the context of LMS app utilisation.

In this study, we adopted the concept of passion as a key affective dimension for analysing learner engagement with LMS apps. Passion denotes an intense urge to devote an individual's full efforts to activities that are deemed meaningful (Anwar et al., 2023). It reflects a sustained, intrinsically motivated engagement with an activity (Astakhova & Porter, 2015). When an individual strongly loves and would love to invest great time and energy in an activity, it shows that the person is passionate about the activity (Wolf et al., 2016). Compared to arousal or dominance, passion not only represents intense positive feelings but also reflects great lasting and intrinsically motivated emotions versus transitory feelings (Astakhova & Porter, 2015). In the context of LMS app usage, passion may manifest as a strong, persistent desire to engage with the app, particularly when it serves as a conduit for acquiring valuable knowledge or skills.

This expanded conceptualisation of affective expressions, which includes arousal, dominance and passion, provides a more comprehensive and specific framework for understanding students' emotional responses to LMS apps. It aims to capture the complex interplay of affective factors that shape students' experiences with educational technology in higher education settings.

Continuous usage intention

Continuous usage intention reflects users' willingness to accept a novel technology and allow it to become an enduring part of changing their regular lifestyle (McLean & Osei-Frimpong, 2019). Sánchez-Prieto et al. (2019) characterised students' continuous intentions as their ongoing willingness to interact with educational technologies. This study defines students' continuous usage intention as their motivation to consistently use an LMS app over time, representing their willingness to engage in the practices provided by the LMS app. Crucially, in educational contexts, this intention develops under conditions of mandatory implementation, where students must navigate the tension between external institutional requirements and internal motivational drivers (Altawalbeh, 2023). Innovation resistance and inertia serve as critical barriers that can undermine this intention, even when the educational value of the system is recognised (Kim & Park, 2023).

Research has emphasised the critical importance of focusing on students' continuous usage intentions for technological tools used in education (Cheng, 2012; Sánchez-Prieto et al., 2019). It is driven by several key factors, including the long-term profitability it ensures for educational institutions and technology providers (Abbasi et al., 2024). While many studies have examined student satisfaction and engagement with LMS service systems, they aimed to foster long-term, continuous use (Xu & Mahenthiran, 2016).

Therefore, students' intentions for continued use serve as a crucial indicator of an LMS app's future prospects and overall viability (Eraslan & Kutlu, 2019).

Interrelationships between students' reactions

The complex interrelationship between perceived app quality, user affective responses and behavioural intentions has been a subject of extensive research across various domains. As for the educational contexts, the ability of e-learning systems to facilitate bidirectional communication between students and instructors, as well as among peers, might be associated with positive emotional responses towards interactive functionalities. Furthermore, Bervell and Umar (2020) have highlighted the critical role of instructor attitudes in shaping students' affective responses to LMS apps, suggesting that positive instructor encouragement may foster student passion for these apps.

Research has identified the mediating role of affective expressions between perceived environmental triggers and behavioural intentions. Goi et al. (2018) found that students' emotions significantly mediated the impact of physical attributes such as layout, facilities and interpersonal interactions on behavioural responses. Cheng (2012) proposed a multidimensional model of the quality of an information service system, and instructor quality as determinants of students' usage intentions. Notably, instructor attitude has emerged as a core attribute of experiential qualities influencing students' attitudes towards e-learning systems (Bervell & Umar, 2020).

The complexity of these relationships is further underscored by the variability in pathways leading to continuous usage intentions across different studies (S. Kumar et al., 2021). The heterogeneity regarding the aforementioned interrelationships suggests that individuals' continuous usage intentions may be simultaneously influenced by both affective expressions and perceived quality attributes of mobile apps, with the relative importance of these factors varying across individuals and contexts.

Integrative S-O-R theory

The conventional S-O-R model in environmental psychology posits a linear causal sequence: external stimuli influence internal affective reactions, which in turn shape behavioural responses (Mehrabian & Russell, 1974). Jacoby (2002) argued that this linear conceptualisation might constrain fully elucidating the dynamic and complex nature of individuals' reactions to environmental stimuli. People's diverse reactions towards the encountered environment may function simultaneously and fail to follow a certain sequence. Consequently, Jacoby proposed an integrative S-O-R model, employing intersecting circles to illustrate the fuzzy boundaries and intricate interrelationships among stimuli, organisms and responses.

Jacoby's (2002) integrative S-O-R model suggested a novel view for this study to explore the dynamic and holistic nature of the influencing process from LMS app quality to students' continuous usage intentions. Students are extremely diverse in terms of their learning capacities, habits and purposes; thus, their behavioural intentions should be explained from holistic and comprehensive viewpoints rather than a single sequence (Abbasi et al., 2024). Additionally, adopting LMS apps is a challenge in an educational context, requiring a comprehensive perspective to explore the bidirectional relationships among technologies, learning content, instructors and students' psychological and behavioural reactions. Different from commercial apps, reciprocity is the fundamental point of LMS apps used in education (Kukulska-Hulme & Viberg, 2018). Reciprocity requires stakeholders to interact frequently in LMS apps, following dynamic and complex flows. Therefore, perceived LMS app quality attributes are captured into the stimulus domain, which represents the external environments of the LMS app system. Students' affective expressions include arousal, dominance and passion from the organism domain. The response domain serves as the basis of students' continuous usage intentions.

Development of research propositions

Complexity theory provided a theoretical foundation for this research model (Figure 1), as it emphasises the multifaceted and nonlinear nature of individual behaviours within complex systems (Ragin, 2008; Woodside, 2013, 2014). This perspective centres on three core principles essential for configurational

analysis (Woodside, 2013): The principle of causal complexity posits that that causal factors can be combined to form multiple configurations that lead to an outcome of interest. Furthermore, the principle of equifinality recognises that multiple distinct sets of conditions may lead to the same outcome, such as high continuous usage intention. Finally, the principle of causal asymmetry asserts that conditions leading to an outcome are not simply the inverse of those leading to its absence; thus, factors that promote app usage do not necessarily explain what inhibits it. With an integration of the two theories in this model, students' multifaceted reactions towards the use of LMS apps can be comprehensively captured and compared. Moreover, it provides the possibility of revealing the patterns that show the simultaneous impacts of stimuli and organisms on students' continuous usage intentions.

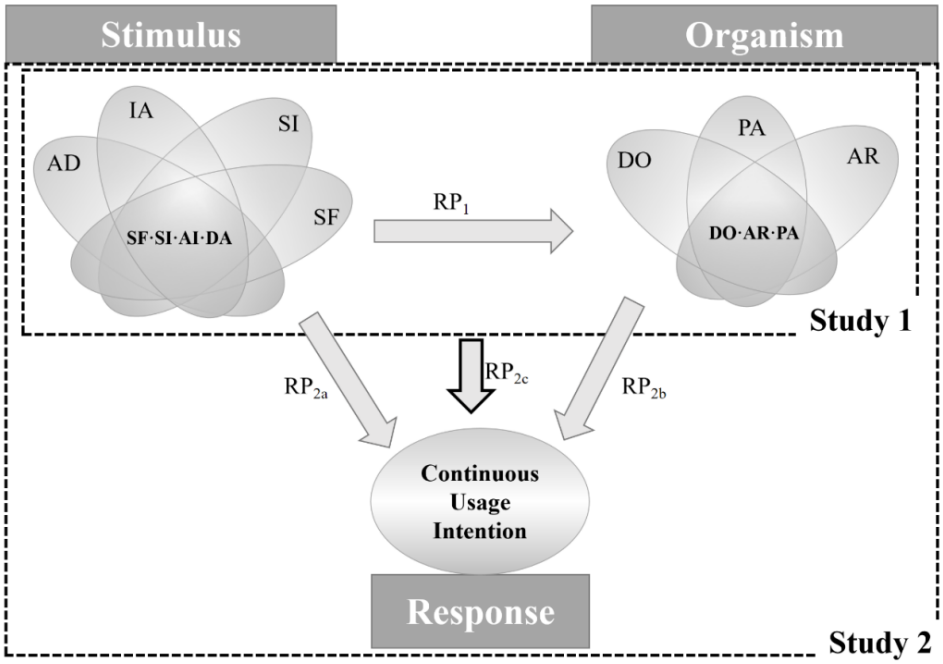

Figure 1. Conceptual framework

Note. AD: aesthetic design; IA: instructor attitude; SI: system interactivity; SF: system functionality; DO: dominance; PA: passion; AR: arousal; CI: continuous usage intention.

While stressing the mixed and contradictory relationships, studies have agreed on the significance of perceived quality attribute of LMS apps and students' affective expressions in leading to users' continuous usage intention (Bervell & Umar, 2020; Cheng, 2012). Thus, in this study, using structural equation modelling to examine the individual causal factors as most studies have done was less appropriate than focusing on configural causal patterns. Therefore, the proposed model encompassed two studies: Study 1 explored how students' affective expressions are developed from antecedent configurations of LMS app quality attributes. Study 2 examined how students' continuous usage intentions are developed based on the configurations of LMS app quality attributes and students' affective expressions.

Configurational relationships between stimulus and organism (Study 1)

Study 1 of the model assumed that all perceived LMS app quality attributes (stimuli) will have an impact on each factor that represents students' affective expressions (organism), including arousal, dominance and passion. The four quality attributes of the LMS app – aesthetic design, instructor attitude, system interactivity and system functionality – were considered antecedents that should have equal opportunities to predict students' affective expressions (organism). However, the question of which antecedents can be simultaneously combined in a configuration and how many such configurations can be developed from the stimulus domain to predict students' affective expressions in the organism domain, required exploration in Research Proposition 1 (RP_1).

- RP_1: There are more than one and equally effective configurations of causal conditions in the stimulus domain that may predict a high level of each element in the organism domain.

RP_1 suggests the existence of multiple pathways through which combinations of LMS app quality attributes may lead to high levels of student affective responses. We conceptualised these pathways as equifinal, meaning that different configurations of quality attributes can result in similarly high levels of affective responses. Furthermore, the relationship between LMS app quality attributes and student affective responses is complex and may be inadequately captured by simplistic, linear modelling approaches.

Configurational relationships between stimulus, organism and response (Study 2)

Study 2 sought to identify all possible causal configurations resulting from the combination of antecedents in the stimulus or organism domain, with the goal of predicting students' continuous usage intentions. This aligns with research that an individual's cognitive and affective reactions can be combined in different configurations to explain behavioural outcomes (Pappas et al., 2016). Thus, the potentially complex and at times contradictory effects of perceived LMS app quality attributes and students' affective expressions on continuous usage intentions can be holistically explored in RP_2:

- RP_2: There are more than one and equally effective configurations of causal conditions (from stimulus and organism domain) that lead to a high level of continuous usage intentions among students.

Research has indicated that individuals' continuous usage intentions of mobile apps can be motivated internally and externally (Hsieh et al., 2021; S. Kumar et al., 2021). Notably, in certain instances of technology use, users' continuous intentions are influenced by the perceived quality attributes of LMS apps. In contrast, in other cases, decisions may be primarily based on affective reactions, such as arousal, when strong perceptions of quality are lacking (Abbasi et al., 2024). Each configuration pattern identified in Study 2, which can lead to continuous usage intentions, is self-sufficient and can serve as an alternative to other configurations. The presence or absence of each stimulus and organism factor in various configurations depends on their specific combinations. Consequently, Study 2 suggested that potential causal configurations predicting continuous usage intentions can be categorised into three groups:

- RP_{2a}: Sufficient configurations of the causal conditions from the stimulus domain result in a high level of continuous usage intentions among students.
- RP_{2b}: Sufficient configurations of the causal conditions from the organism domain result in a high level of continuous usage intentions among students.
- RP_{2c}: Sufficient configurations that combine the causal conditions from the stimulus and organism domain result in a high level of continuous usage intentions among students.

Method

Study context and data collection

An online survey was conducted to collect data for testing the research proposition. The target population comprised undergraduate students who utilised the Chaoxing LMS mobile application for educational purposes at universities in China. Chaoxing is a personalised application that integrates learning resources, course slides from instructors, learning tasks and course-related reading materials or videos, along with quiz questions.

To ensure ethical compliance and reduce potential biases, we distributed anonymous electronic questionnaires to participating students from 13 universities across different regions of China. During the data collection period (from March to May 2024), a total of 417 responses were obtained. After excluding incomplete responses, 400 valid questionnaires were retained for analysis. The questionnaire consisted of three sections: the first section filtered out participants who were not currently enrolled in higher

education. The second section explored students' perceptions of the functional and experiential quality attributes of the app, their affective expressions when using the learning app and their continuous usage intentions. The third section collected demographic information.

All measurement scales were adapted from previous research (Table A1) and measured by 7-point Likert scales, from *strongly disagree* (1) to *strongly agree* (7). Two criteria were used for scale selection: First, the reliability and validity of the selected scales should meet the standard requirement. Second, the scales should cover the definitions of corresponding constructs in this study.

The majority of the participants were female (74%); more sophomores (34.5%) and juniors (27.8%) than seniors (13.8%) participated in the survey (Table A2).

Preliminary analysis

To assess the measurement model (Table 1), the software smartPLS 3.2.8 was applied. The preliminary analysis indicated that all the constructs were valid and reliable. First, the reliability and convergent validity were upheld, with all indicator loadings above 0.5, the average variance extracted values and composite reliability values of all constructs exceeded the thresholds of 0.5 and 0.7 respectively (Hair et al., 2019; Hair et al., 2021). Second, Dillon-Goldstein's rho value was above 0.7, which further demonstrates the adequate reliability of all the constructs (Table 2) (Do Valle & Assaker, 2016). Third, the discriminant validity was evaluated according to Henseler et al. (2015), which suggested the heterotrait-monotrait value should be ideally less than 0.85. Thus, Table 2 indicates the acceptable discriminant validity in this model.

Table 1
Measurement model

Constructs	Indicator	Factor loading	*Mean*	*SD*	CR	AVE	Cronbach's α
Aesthetic design	AD1	0.932	4.20	1.425	0.962	0.807	0.951
	AD2	0.926	4.23	1.437			
	AD3	0.946	4.09	1.413			
	AD4	0.921	4.02	1.484			
	AD5	0.824	4.65	1.414			
	AD6	0.834	4.44	1.439			
Instructor attitude	IA1	0.856	4.93	1.449	0.930	0.691	0.911
	IA2	0.795	5.37	1.352			
	IA3	0.881	4.78	1.450			
	IA4	0.824	5.48	1.272			
	IA5	0.853	4.73	1.482			
	IA6	0.773	5.42	1.270			
System interactivity	SI1	0.842	3.89	1.599	0.916	0.732	0.878
	SI2	0.845	4.75	1.507			
	SI3	0.883	4.52	1.487			
System functionality	SF1	0.838	5.35	1.271	0.932	0.698	0.914
	SF2	0.785	4.51	1.536			
	SF3	0.752	5.65	1.211			
	SF4	0.896	5.07	1.353			
	SF5	0.905	5.20	1.299			
	SF6	0.824	5.21	1.381			
Dominance	DO1	0.861	4.74	1.395	0.922	0.748	0.888
	DO2	0.877	5.00	1.393			
	DO3	0.863	5.13	1.243			
	DO4	0.858	5.06	1.276			
Arousal	AR1	0.988	3.68	1.644	0.987	0.974	0.974
	AR2	0.987	3.56	1.658			

Constructs	Indicator	Factor loading	*Mean*	*SD*	CR	AVE	Cronbach's α
Passion	PA1	0.917	3.76	1.595	0.962	0.894	0.940
	PA2	0.969	4.01	1.684			
	PA3	0.951	3.61	1.589			
Continuous usage intention	CI1	0.910	4.46	1.587	0.958	0.883	0.934
	CI2	0.953	4.11	1.613			
	CI3	0.955	4.11	1.658			

Note. AVE = average variance extracted; CR = composite reliability.

Table 2
Discriminant validity (heterotrait-monotrait ratios)

Constructs	AD	AR	CI	DO	IA	PA	SF	SI
AD								
AR	0.758							
CI	0.737	0.753						
DO	0.639	0.614	0.704					
IA	0.502	0.425	0.564	0.681				
PA	0.782	0.897	0.836	0.64	0.463			
SF	0.604	0.491	0.649	0.865	0.769	0.538		
SI	0.728	0.709	0.771	0.787	0.801	0.748	0.808	

Note. AD: aesthetic design; AR: arousal; CI: continuous usage intention; DO: dominance; IA: instructor attitude; PA: passion; SF: system functionality; SI: system interactivity.

Since data were collected from a single source, the common method variance (CMV) was assessed according to the value of variance inflation factors (VIFs) and the correlation matrix procedure (Kock, 2015; Kock & Lynn, 2012). To rule out CMV concerns, the VIFs should ideally not exceed 3.3 when all variables are regressed against a theoretically unrelated marker variable. The results indicated that the VIFs for all constructs were less than 3.3, and the correlations between constructs were below 0.8 (Table 3). These findings demonstrate that CMV was not a concern in this study.

Table 3
Inter-correlations between constructs

Construct	AD	IA	SI	SF	DO	AR	PA	CI
AD	1							
IA	.470**	1						
SI	.668**	.687**	1					
SF	.572**	.699**	.698**	1				
DO	.590**	.612**	.678**	.781**	1			
AR	.730**	.406**	.679**	.476**	.574**	1		
PA	.716**	.425**	.677**	.507**	.580**	.816**	1	
CI	.696**	.522**	.681**	.606**	.642**	.718**	.767**	1

Note. AD: aesthetic design; IA: instructor attitude; SF: system functionality; SI: system interactivity; DO: dominance; AR: arousal; PA: passion; CI: continuous usage intention.
** indicates that the results of the correlations were significant at the 0.01 level.

Correlation and contrarian case analysis

The analysis also detected asymmetrical relationships occurring among constructs, based on the correlations and contrarian cases analysis. The correlations between constructs were below 0.8. Contrarian case analysis identified both positive and negative contrarian cases in this study (see the cases in bold in Table 4). These findings indicate that fsQCA would be an appropriate method to explore the possible asymmetrical relationships in this model.

Table 4
An example of the contrarian case analysis results

Construct		Continuous usage intention					Total
		1	2	3	4	5	
Instructor attitude (Phi = 0.601, p < 0.001)	1	25	20	29	**6**	**1**	81
		30.9%	24.7%	35.8%	**7.4%**	**1.2%**	100%
	2	11	23	18	**18**	**6**	76
		14.5%	30.3%	23.7%	**23.7%**	**7.9%**	100%
	3	11	9	23	33	6	82
		13.4%	11.0%	28.0%	40.2%	7.3%	100%
	4	**12**	**11**	16	20	23	82
		14.6%	**13.4%**	19.5%	24.4%	28.0%	100%
	5	**6**	**6**	7	16	44	79
		7.6%	**7.6%**	8.9%	20.3%	55.7%	100%
Total		65	69	93	93	80	400
		16.3%	17.3%	23.3%	23.3%	20.0%	100%
Construct		Passion					Total
		1	2	3	4	5	
Instructor attitude (Phi = 0.601, p < 0.001)	1	25	23	27	**5**	**1**	81
		30.9%	28.4%	33.3%	**6.2%**	**1.2%**	100%
	2	14	24	15	**21**	**2**	76
		18.4%	31.6%	19.7%	**27.6%**	**2.6%**	100%
	3	11	20	15	30	6	82
		13.4%	24.4%	18.3%	36.6%	7.3%	100%
	4	**16**	**12**	17	19	18	82
		19.5%	**14.6%**	20.7%	23.2%	22.0%	100%
	5	**9**	**11**	9	15	35	79
		11.4%	**13.9%**	11.4%	19.0%	44.3%	100%
Total		75	90	83	90	62	400
		18.8%	22.5%	20.8%	22.5%	15.5%	100%

Note. Cases in bold represent contrarian cases.

fsQCA

Extending beyond conventional variance-based methods, fsQCA is a case-based analytical technique well suited to capture the complex and dynamic interplay between students' perception, affective responses and behavioural intentions regarding LMS app usage (Ragin, 2008). Rather than examining net effects, it focuses on set-theoretic analysis by conceptualising measured constructs as causal or outcome conditions, thereby enabling the identification of alternative configurations (Ragin, 2008). These configurations represent distinct combinations of students' perceptions – encompassing both functional and experiential quality attributes of LMS apps, and their affective feelings – that lead to strong continuous usage intention.

The first analytical step in fsQCA is data calibration, which means that raw data must be transformed into fuzzy sets with values ranging from 0 to 1, following Ragin's (2008) direct calibration method. In this study, three anchor points (1.0 = *full membership*, 0 = *full non-membership* and 0.5 = the *crossover point of maximum ambiguity* regarding membership) were established for data calibration. For instance, to calibrate continuous usage intention, the raw data was classified into five quintiles. Then, the highest (281.5), middle (212.5) and lowest (106) quintiles were set as 0.95, 0.50 and 0.05 membership, respectively. Other conditions were calibrated following the same procedure.

Following calibration, the primary analysis involves constructing a "truth table" (Ragin, 2008, p. 87; Schneider & Wagemann, 2012, p. 404). After iterative testing, a minimum case frequency of 1 was set for inclusion, and a consistency threshold of 0.84 was selected for subsequent analysis (Fiss, 2011). This

threshold of 0.84 represents an optimal balance for social science research, guided by methodological conventions. It is sufficiently high to ensure that identified configurations are reliable subsets of the outcome (exceeding the common benchmark of 0.80). It also ensures the causal pathways relevant to understanding complex human behaviour (Fiss, 2011; Woodside, 2014).The truth table algorithm yields complex, intermediate and parsimonious solutions (configurations or combinations).

Conditions within a solution are classified as either core or peripheral (Ragin, 2008). Core conditions are strongly associated with the outcome and play an essential role across configurations, while peripheral conditions contribute but are less central (Ragin, 2008). In this study's results tables, core conditions are indicated by large circles (●) and peripheral conditions by small circles (•). These distinctions are derived by comparing intermediate and parsimonious solutions. In the present analysis, the intermediate and parsimonious solutions were identical, indicating that no further simplification was required. Configurations were considered meaningful only if their overall consistency exceeding 0.85 and their overall coverage was higher than 0.05 (Ragin, 2008; Woodside, 2013).

Both raw and unique coverage are reported for each solution. Raw coverage indicates the empirical relevance of a configuration by showing the proportion of cases with the outcome that it explains. Unique coverage indicates the proportion explained only by that specific configuration. In line with configurational analysis guidelines, the overall coverage and consistency are key indicators of a solution's explanatory power and set-theoretic validity (Ragin, 2008). The overall coverage values in this study ranged from 0.55 to 0.89 (all >0.05), indicating that the identified configurations accounted for a substantial share of cases exhibiting high continuous usage intention. Even configurations with lower unique coverage represent important, distinct pathways for specific students subgroups, which is consistent with the principles of equifinality and causal asymmetry expected in complex phenomena (Fiss, 2011).

Findings

The combinations of core causal conditions leading to strong outcomes in the organism domain (Study 1) and students' continuous usage intentions (Study 2) are discussed as follows (Figure 2):

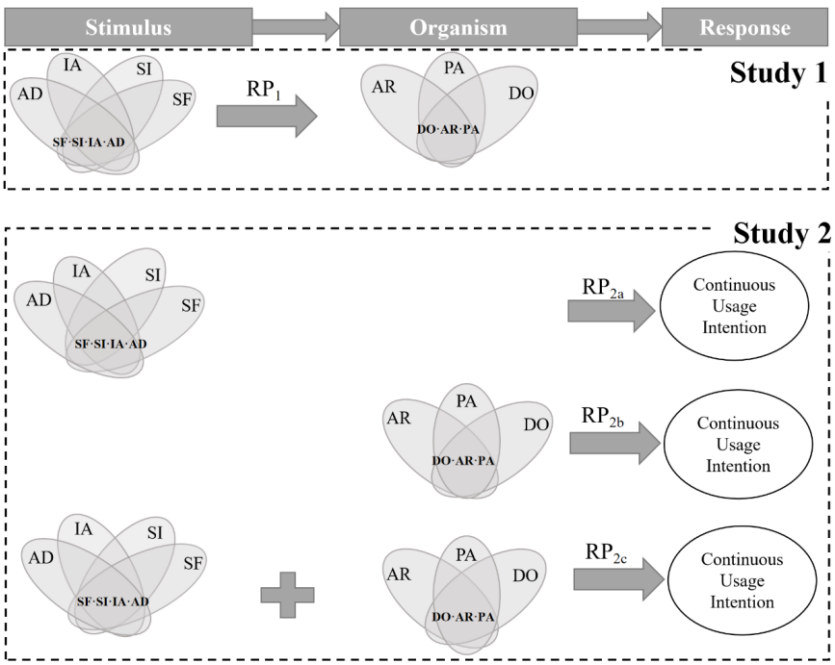

Figure 2. The developing process of the outcomes of interests

Note. AD: aesthetic design; IA: instructor attitude; SI: system interactivity; SF: system functionality; DO: dominance; AR: arousal; PA: passion.

Study 1: Solutions lead to high levels of organism response from stimulus

Table 5 presents the relationships between LMS app quality attributes (stimulus) and users' affective response (organism), supporting RP_1.

Table 5
Predicting high scores in student affective feelings (organism) with the use of learning app

Causal conditions	Dominance		Arousal		Passion
	(1)	(2)	(1)	(2)	(1)
Aesthetic design			●		●
Instructor attitude	●			●	
System interactivity		●	●	●	●
System functionality	●*	●*		●	●
Raw coverage	0.65	0.65	0.57	0.46	0.51
Unique coverage	0.11	0.11	0.11	0.05	0.33
Consistency	0.87	0.88	0.87	0.84	0.86
Overall consistency	0.86		0.84		0.85
Overall coverage	0.76		0.65		0.59

Note. The black circles represent core conditions (strongly contributing factors whose presence is crucial in the corresponding pathway). Blank cells represent "do not care". The * indicates the condition was confirmed as a necessary condition.

To predict a strong sense of dominance among students using LMS apps, high system functionality, a functional quality attribute, emerged as a necessary and core causal condition in two alternative solutions, underscoring its significance. While necessary, high system functionality alone is insufficient to lead to a high level of dominance. Both solutions suggest the high system functionality must be combined with an experiential quality attribute. This attribute could be either the instructor's positive attitude (row coverage = 0.65; consistency = 0.87) or a high level of system interactivity (row coverage = 0.57; consistency = 0.88) in leading to a high level of dominance.

In terms of sufficient solutions that are capable of predicting students' sense of arousal when utilising LMS apps, we identified two alternative solutions. A pivotal casual factor in both these solutions ought to be an experiential quality attribute (high level of system interactivity). However, solely relying on system interactivity is insufficient in predicting robust arousal among students. Solution 1 suggested a combination of system interactivity with a functional quality attribute (high quality of aesthetic design) of the LMS apps (row coverage = 0.57; consistency = 0.87). Solution 2, on the other hand, proposed a combination of effective system interaction with another functional quality attribute, the high system functionality, as well as an experiential quality attribute (instructors' positive attitude) (row coverage = 0.46; consistency = 0.84).

If the objective is to predict strong passion among students when utilising LMS apps, one comprehensive solution is identified. This solution suggests that one experiential quality attribute (effective system interaction) and two functional quality attributes (high quality of system functionality and aesthetic design) should serve as the core causal conditions, which should be combined simultaneously to achieve the desired outcome (row coverage = 0.51; consistency = 0.86).

Study 2: Solutions lead to high level of students' continuous usage intentions

Sufficient configurations that lead to students' strong intentions to continue using LMS apps were detected under three circumstances, supporting RP_{2a}, RP_{2b}, and RP_{2c}.

From stimulus to response (RP_{2a})

Table 6 indicates that one solution is sufficient to explain students' strong intention to continuously use the LMS apps when the causal combinations are derived solely from students' perceptions of the LMS apps (stimulus stage) (overall coverage = 0.55; overall consistency = 0.90), which supports RP_{2a} (Sufficient

configurations of the causal conditions from the stimulus stage may lead to high level of continuous usage intentions among students). Students would continue to use the LMS apps to complement their learning experience when they perceive positively two functional quality attributes (aesthetic design and system functionality) and one experiential quality attribute (system interactivity) of the LMS apps. However, in this solution, the experiential quality attribute of instructor attitude is not identified as a core causal condition.

Table 6
Predicting high scores in students' continuous usage intention from the stimulus stage

Causal conditions from stimulus	Continuous usage intention (1)
Aesthetic design	●
Instructor attitude	
System interactivity	●
System functionality	●
Raw coverage	0.55
Unique coverage	0.55
Consistency	0.90
Overall consistency	0.90
Overall coverage	0.55

Note. The black circles represent core conditions (strongly contributing factors whose presence is crucial in the corresponding pathway). Blank cells represent "do not care".

From organism to response (RP_{2b})

Table 7 summaries the results for RP_{2b} (Sufficient configurations of the causal conditions from the organism stage may lead to high level of continuous usage intentions among students). One solution from the organism stage (students' feelings) is sufficient to explain students' strong intentions to use the LMS apps. This solution identifies students' feelings of dominance and passion as core causal conditions, combined with their feelings of arousal when using the LMS apps as a peripheral condition (overall coverage = 0.55; overall consistency = 0.90).

Table 7
Predicting high scores in students' continuous usage intention from the organism stage

Causal conditions from organism	Continuous usage intention (1)
Dominance	●
Arousal	•
Passion	●
Raw coverage	0.59
Unique coverage	0.59
Consistency	0.89
Overall consistency	0.59
Overall coverage	0.89

Note. The large black circles represent core conditions (strongly contributing factors whose presence is crucial in the corresponding pathway); the small black circles represent peripheral conditions (supporting factors that appear in the configuration but are less central). Blank cells represent "do not care".

From the combination of stimulus and organism to response (RP_{2c})

Interestingly, multiple solutions contribute to a high level of continuous usage intentions when combining casual conditions from the stimulus stage (students' functional or experiential perceptions of the LMS apps' quality attributes) and organism stage (affective feelings), which supports RP_{2c}: Sufficient configurations that combine the causal conditions from the stimulus and organism stage may lead to high level of continuous usage intentions among students (Table 8). Solution 1 highlights one functional quality attribute (high quality of system functionality), two experiential quality attributes (effective system interaction and instructors' positive attitude) of LMS apps, and students' feeling of dominance as the core

casual conditions that contribute to students' strong intentions to continually use the LMS apps when combined peripherally with either high quality of aesthetic design (Solution 1a) or arousal and passion (Solution 1b).

Table 8
Predicting high scores in students' continuous usage intention from the combination of stimulus and organism stage

Causal conditions from stimulus and organism	Continuous usage intention				
	(1a)	(1b)	(2)	(3)	(4)
Aesthetic design	•		●	●	•
Instructor attitude	●	●			●
System interactivity	●	●	●		
System functionality	●	●		●	●
Dominance	●	●	●	●	
Arousal		•	•	•	●
Passion		•	●	●	●
Raw coverage	0.43	0.40	0.47	0.47	0.42
Unique coverage	0.06	0.03	0.03	0.02	0.03
Consistency	0.92	0.94	0.94	0.94	0.94
Overall consistency	0.90				
Overall coverage	0.63				

Note. The large black circles represent core conditions (strongly contributing factors whose presence is crucial in the corresponding pathway); the small black circles represent peripheral conditions (supporting factors that appear in the configuration but are less central). Blank cells represent "do not care".

In the remaining three solutions for developing students' continuous usage intentions, all causal conditions at the stimulus or organism stage played essential roles, albeit through different configurations. In Solutions 2 and 3, students' feelings of passion and dominance are core conditions while arousal is a peripheral condition. These should be combined alternatively with two functional quality attributes of the LMS apps (high quality of system functionality and aesthetic design) in Solution 2, or one functional quality attribute (good aesthetic design) and one experiential quality attribute (effective system interaction) in Solution 3.

Solution 4 also demonstrates an effective causal pattern, combining four core conditions (students' strong feelings of passion, arousal, their positive perception of system functionality, and instructor attitude), as well as good aesthetic design as a peripheral condition, leading to students' high level of continuous usage intention of the LMS apps (row coverage = 0.42; consistency = 0.94).

Comparisons in Study 2

Three research propositions (RP_{2a}, RP_{2b}, RP_{2c}) shared the same outcome of interests but provide distinct solutions, depending on the origination of causal conditions. First, when considering the stimulus and organism stages separately, either provides a solution to achieve strong intentions for continued use of LMS apps among students. Second, when combining the stimulus and organism stages, four effective solutions emerge. In these four solutions, both stimulus and organism factors contribute core causal conditions. For example, students' feeling of arousal is not a core causal condition in the solution derived solely from the organism stage but is considered important in the fourth solution generated from a combination of stimulus and organism stage. Similarly, instructors' positive attitude is not identified as a core condition in the solution generated exclusively from the stimulus stage but is considered a core condition in Solution 1a, 1b and 4 when the stimulus stage is combined with the organism stage. Consequently, this study captures the causal asymmetry within the phenomena of students' reactions to LMS apps usage. In other words, Stimulus conditions may or may not be present in various configurations predicting strong continuous usage intentions, depending on their combination with organism conditions.

Conclusion

This study suggests that, within the context of higher education, students' affective expressions regarding the use of LMS apps can be predicted by various configurations that integrate perceived LMS app quality attributes. Furthermore, students' perceptions of LMS app quality attributes and their affective expressions can be combined to create configurations that ultimately influence students' intentions for continuous usage. The findings suggest that, to achieve a strong sense of dominance among students, system functionality is a more critical attribute than others, serving as a necessary condition. Additionally, to foster a strong sense of dominance, arousal and passion among students, system functionality and interactivity are considered more important than other quality attributes of LMS applications, as they are consistently present in nearly all solutions. In contrast to Pappas et al. (2016), our findings suggest that aesthetic design can contribute to strong arousal in one of the solutions. It suggests that some students may experience positive emotions and inspiration when the aesthetic design of the LMS app is perceived positively, aligning with the findings of S. Kumar et al. (2021).

Several solutions that enhance students' continuous usage intentions of LMS apps are identified. Each solution arises independently from either the stimulus domain or the organism domain. In contrast, combining the four quality attributes of LMS apps from the stimulus domain with the three affective expressions from the organism domain generates an even greater number of solutions (four). It indicates that, regardless of students' existing perceptions of LMS app quality, they also take their affective feelings into account before deciding to continue using these apps. The finding supports the idea that affective reactions significantly influence individuals' behavioural intentions (Hsieh et al., 2021). Specifically, in the absence of stimulus conditions, three affective expressions contribute to strong continuous usage intention, with arousal playing a peripheral role compared to the core roles of dominance and passion. A similar pattern is observed when both stimulus and organism are present; however, the significance of dominance diminishes because one solution (Solution 4) does not necessitate its inclusion.

When organism conditions are absent, the findings indicate that instructor attitude is not significant ("do not care"). However, when both organism and stimulus conditions are present, the importance of instructor attitude increases, as it is included as a core element in multiple solutions (Solution 1a, 1b and 4). This indicates that when students have not developed strong emotional associations with the LMS apps, they tend to base their behavioural decisions more on their functional perceptions of the system quality. Notably, aesthetic design and system interactivity appear to be less critical factors, as they are not included in all four solutions that combine both stimulus and organism condition to predict strong continuous usage intentions. This suggests that for some students with strong affective responses to the LMS apps, aesthetic design and system interactivity may not be crucial determinants in their decisions to continue using the app.

Theoretical contributions

This study makes several theoretical contributions. Primarily, it considers students' affective expressions and continuous usage intentions as two significant types of reactions towards the use of LMS apps. Research has largely focused on students' engagement or satisfaction (Aljohani et al., 2019; Xu & Mahenthiran, 2016), with limited attention to affective factors or students' intentions for continued use. Thus, this study addresses a significant research gap by examining these under-studied aspects in the context of LMS app usage in higher education.

Second, this study adds to the existing literature on the relationships between LMS app quality attributes, students' affective expressions, and continuous usage intention by applying an integrative S-O-R theory (Jacoby, 2002). This approach is distinctive in the educational field, contrasting with the conventional S-O-R sequence often adopted in previous studies (e.g., Anwar et al., 2023; Goi et al., 2018). A key innovation of this study is the combined consideration of functional and experiential quality attributes of LMS apps alongside students' affective expressions as equally important factors contributing to

continuous usage intentions. This approach captures the complex reality that students' perceptions of an app's quality attributes remain influential even as they develop affective responses to the LMS app.

Third, this study introduces an innovative methodological approach for investigating students' psychological reactions. By employing fsQCA, a configural analysis technique, this research examined individual-level data patterns rather than relying solely on the linear relationships typically explored through regression-based techniques. This method enables the identification of asymmetric relationships between students' perceptions and reactions, thereby exploring the complex and dynamic nature of human psychological processes in educational settings. The application of fsQCA in this context represents a significant advancement, as it allows for an understanding of the intricate interplay between various factors influencing students' responses to LMS apps.

Additionally, the findings were discovered within the Chinese higher education setting, providing important contextual insights for existing theory. It reveals that system functionality, aesthetic design and system interactivity serve as essential conditions in the configurations that lead to students' continuous usage intentions of LMS apps. These findings are closely linked to distinctive features of the Chinese educational environment, characterised by large-class teaching, an instructor-centred culture and students' reliance on technological tools, which indicates that the identified pathways are context dependent. The study extends Wu's (2025) finding that Chinese educational systems emphasise centralised progress monitoring by demonstrating how such structures interact with individual affective responses to produce continuous usage intentions, revealing that mandatory usage contexts require distinct configurational pathways compared to autonomy-focused environments.

Managerial implications

The findings offer valuable insights for the primary stakeholders in higher education. Specifically, the identified causal configurations enable the formulation of evidence-based recommendations for LMS app designers, institutional administrators and instructors. At the system level, institutions should implement faculty development programs to enhance instructors' digital literacy and their capacity to leverage LMS features for increasing student interaction (Gunawan et al., 2024; Kim & Park, 2023). Additionally, infrastructure support – including reliable network connectivity and server capacity – is essential to reduce technical barriers that undermine sustained engagement (Alumona & Akinseinde, 2023; Arifin et al., 2023).

Firstly, LMS app designers can strategically utilise these findings to guide product development priorities. The identification of LMS apps system functionality as a necessary condition for stimulating student dominance indicates that such core feature as assignment submission, content delivery and grade management, are essential and should therefore be treated as key priorities in the design process, thereby supporting sustained student continuous usage inattention. This finding is particularly pertinent to large-enrolment courses in Chinese higher education, where large class sizes can constrain teacher-student interaction and make learning activities more difficult to organise effectively (Zhang & Fisher, 2022) . This situation places a premium on LMS apps that can efficiently handle core administrative and content delivery tasks. Simultaneously, the identification of system interactivity and aesthetic design as sufficient conditions within a configuration that include system functionality and that lead to high level of student usage, suggests that significant investment should also be directed towards enhancing system interactivity. This would help transform the LMS app from a passive repository into an active learning community hub, achievable through advanced communication channels and interactive elements that facilitate effective peer and instructor's interaction. Given the continuing influence of instructor-centred teaching practices in many Chinese higher education settings (Ying & Briffett-Aktaş, 2024; Zhang & Fisher, 2022), fostering peer-to-peer interaction in digital tools needs targeted design efforts, particularly in system interactivity and aesthetics, to effectively shift engagement patterns within LMS apps. Similarly, aesthetic design should be strategically valued to create a clear, consistent and professionally appropriate interface that actively supports the student learning experience. Given Chinese students' extensive everyday engagement with mobile apps incorporating sophisticated functionality and interactive design features, their broader digital experiences are likely to shape the standards against which they evaluate

LMS apps (Chen et al., 2023). LMS app designers should therefore address students' expectations regarding functionality, interactivity, and aesthetic quality.

Secondly, institutional administrators can leverage these findings to strategically build an educational ecosystem that enhances the effective adoption of the LMS apps. Institutional administrators should implement comprehensive faculty development programmes combining technical training with pedagogical strategies for fostering student engagement (Kim & Park, 2023). Digital literacy initiatives should target both instructors and students to ensure equitable access to LMS benefits (Alumona & Akinseinde, 2023; Gunawan et al., 2024). Infrastructure investments – including stable networks, server capacity and technical support systems – are prerequisites for reducing innovation resistance and enabling sustained usage (Arifin et al., 2023; Kim & Park, 2023). This need is particularly relevant in Chinese university settings seeking to expand blended and digitally supported learning, as instructors require appropriate pedagogical development and institutional suport to translate their existing subject expertise into effective digital teaching practices (Zhang & Fisher, 2022). Additionally, institutional administrators should collaborate with LMS app designers to analyse metrics related to core elements, such as functionality usage and interaction rates. Data-informed approach enables institutions to identify systemic weaknesses and guide targeted support or system improvements. As system functionality or interactivity improve, an institutional culture that encourages broader faculty engagement can be cultivated. Ultimately, this leads to an enhanced student learning experience and contributes to the organic development of a robust, positive learning ecosystem.

Thirdly, instructors serve as the crucial interface between students and LMS app. Institutions should provide ongoing training and just-in-time technical support to enable instructors to model positive digital attitudes and effectively utilise interactive features (Kim & Park, 2023). Our findings indicate that a positive instructor attitude, when combined with effective aesthetic design, fosters a sense of dominance among most students and forms a potent pathway to sustained LMS app usage. Thus, instructors should demonstrate enthusiasm by consistently and effectively using the LMS app's communication tools and by providing timely and personalised feedback, thereby cultivate this essential sense of student dominance. Within Chinese higher educational context, where lecturer-student relationships have traditionally been characterised by relatively high power distance, instructors' visible and positive engagement with LMS apps may function as an important social cue that encourages student participation (Ying & Briffett-Aktaş, 2024), a positive digital attitude from instructors serves as a powerful motivator for student participation on LMS apps. Additionally, the findings also suggested that while some students are primarily driven by the LMS app's functional utility, others require engaging and interactive tasks. Accordingly, instructors should also adopt a differentiated teaching approach when integrating LMS apps into instruction, aiming to stimulate positive emotional responses in students, such as feelings of arousal and passion. This approach is particulatly appropriate in Chinese higher education, where students differ in their levels of digital competence and learning needs, and may therefore respond differently to interactie and exploratory digital learning activities (He & Zhu, 2017; Zhang & Fisher, 2022).

Limitations and future research

The study has some limitations that can be addressed in future research. Firstly, the research data were collected from China, specifically targeting undergraduate students who have used the Chaoxing LMS app in courses. This may limit the generalisation of the findings. Therefore, further studies can adapt this model to examine students' reactions to LMS app adoptions in other countries and identify any differences in diverse contexts. Secondly, this study identified four quality attributes of LMS app and three affective expressions that can be combined in various solutions contributing to students' strong continuous usage intentions. It highlights the importance of both LMS app quality and students' affections. Further studies on technological tools used in teaching and learning activities can extend this model by exploring more quality attributes of the tool and students' affective expressions based on different demographic or psychological characteristics.

Author contributions

Xi Fang: Conceptualisation, Investigation, Writing – original draft, Writing – review and editing; **Liangjie Zhu**: Data curation, Investigation; Formal analysis; **Shuang Xin**: Conceptualisation, Supervision, Writing – review and editing.

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Corresponding author: Shuang Xin, xinshuang009@163.com

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Appendix

Table A1

The measurements of constructs

Constructs	Sources
Aesthetic design	Cyr et al. (2006); Merikivi et al. (2017)
1. The screen design (i.e., colors, boxes, menus, etc.) of this learning app is attractive.	
2. This learning app has good graphic design.	
3. This learning app has visually appealing overall look and feel.	
4. Overall, I find that this learning app looks attractive.	
5. This learning app looks professionally designed.	
6. The graphics in this learning app are meaningful.	
Instructor attitude	Cho et al. (2009); Ozkan & Koseler (2009)
1. The instructor timely returns learners' emails via this learning app.	
2. The instructor frequently updates lecture notes for learners on this learning app.	
3. The instructor promptly responds to learners' questions via this learning app.	
4. The instructor friendly responds to learners' concerns via this learning app.	
5. The instructor is good at communication with learners via this learning app.	
6. Overall, the instructor's attitude is conducive to learners' learning via this learning app.	
System interactivity	Cho et al. (2009); Pituch & Lee (2006)
1. This learning app enables interactive communication among learners.	
2. This learning app enables interactive communication between the instructor and learners.	
3. The communicational tools in this learning app are effective.	
System functionality	Cho et al. (2009); Pituch & Lee (2006)
1. This learning app offers multimedia types of course content.	
2. This learning app allows me control over the pace of my learning.	
3. This learning app provides the means for taking tests and turning in assignments.	
4. This learning app presents course content in a readable and well-organised format.	
5. This learning app clearly presents course content.	
6. This learning app offers flexibility in learning as to time and place.	
Dominance	Mazaheri et al. (2012)
1. I felt that I had a lot of control over my usage experiences at this learning app.	
2. While I was on this learning app, I could choose freely what I wanted to see.	
3. While using the learning app, my actions decided the kind of experiences I got on this app.	
4. While I was on this learning app, I controlled what happened in my online information searches.	
Arousal	Huang et al. (2017)
1. When I use this learning app, I think it's very exciting.	
2. When I use this learning app, I feel very excited.	
Passtion	Hemsley-Brown & Alnawas (2016)
1. I am passionate about this app.	
2. I have real trust in this app.	
3. I feel really close to this app.	
4. This app is really appealing to me.	
5. This app makes me feel great delight.	
Continuous usage intention	Fang (2017)
1. I intend to continue using this learning app rather than discontinue its use.	

Constructs	Sources
2. I intend to increase my use of this learning app in the future.	
3. If I could, I would like to continue my use of this learning app.	

Table A2

Profile of the respondents (N = 400)

	Category	Frequency	Percentage (%)
Gender	Male	104	26.0
	Female	296	74.0
Grade	Freshman	96	24.0
	Sophomore	138	34.5
	Junior	111	27.8
	Senior	55	13.8
Total		400	100