

Exploring the Antecedents of Online Learning Satisfaction: Role of Flow and Comparison Between use Contexts

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Abstract

Learners' satisfaction plays a critical role in the success of online learning platform. Many factors that affect online learning satisfaction have been addressed by previous studies. However, the mechanisms by which these factors are associated with online learning satisfaction are not sufficiently clear. Moreover, the difference in the antecedents of online learning satisfaction between two use contexts- Mobile context and PC context, was rarely examined. Based on the Stimulus-Organism-Response (S-O-R) framework, we investigate the key factors (self-efficacy, social interaction, platform quality, teacher's expertise) affecting flow and highlights its role in online learning satisfaction, which is empirically tested through an online survey of 333 online learners. Results show that self-efficacy, teacher's expertise, platform quality, and social interaction positively affect online learning satisfaction through the mediation of flow. Use contexts not only moderate the relationship between flow and online learning satisfaction, but also between social interaction, platform quality, teacher's expertise, and flow. These new findings expand educators with ways to increase flow, add to knowledge about the relationship between flow and online learning satisfaction and provide references for online learning platforms to enhance learners' online learning satisfaction under multiple-version affordances.

Keywords: online learning satisfaction, flow, use contexts, S-O-R framework.

1 Introduction

The outbreak of the COVID-19 pandemic in 2020 spread rapidly around the world, causing huge ripples in education in different countries [32]. Isolation measures have impacted the learning and education activities of colleges and universities, leading traditional offline learning to be transferred

to online [51], thus the demand for online learning has exploded. Considering the spread of the epidemic, most American universities temporarily shifted most of their teaching activities online [73]. For example, Harvard University, Stanford University, Massachusetts Institute of Technology, and many other universities have all announced to set up online courses for students on campus. Besides, Romanian scholars have developed an online platform to actively facilitate and support the publication of high-quality scientific literature produced in their country [61]. The Chinese government has put forward the policy of "suspending classes, ongoing learning", and learning informatization are rapidly advancing under the leadership of the government. Online learning has become an inevitable trend in the development of global education [8].

With this trend, an increasing diversity of technology platforms have been adopted to support online learning [64]. For example, learning management systems (LMS) are acknowledged as one of the most essential online learning platforms, which facilitates online learning without the time and space constraints [46]. The LMS can support learners in having classes, writing assignments, taking exams online, so the quality of online learning is influenced by LMS. Further, the LMS was recognized as an irreplaceable emergency learning tool for the transition from traditional learning to online learning during the COVID-19 pandemic. Although LMS is continuing to develop and is expected to continue, the rapid growth of the technology platforms does not mean that online learning will bring learners a positive learning experience. Even many learners have suffered reduction in their satisfactions to online learning after the first experiences. This necessitates a deeper study of the antecedents of online learning satisfaction.

Research on online learning satisfaction have become a hotspot attracting much attention. Hiltz first proposed the concept of online learning, which refers to placing the homepage of a course and related materials on the PC to form shared virtual learning space to achieve a face-to-face (FTF) learning [28]. Malaysian scholars Ramayah and Lee used structural equation models to study system characteristics and online learning satisfaction, aiming to reveal the relationship between online learning system quality, information quality, service quality and learning satisfaction [57].

Though scholars have done a great deal of theoretical exploration and empirical analysis on online learning, there are still problems that need to be studied. First, unlike traditional offline learning, online learning context allows for greater flexibility in learning and more intelligent forms in teaching. Therefore, it cannot be determined whether the factors that influence the learning satisfaction to traditional offline learning can also apply to online learning contexts. Secondly, fewer scholars have introduced mediating effect into the study of online learning satisfaction models, especially there are scarce researches in the literature that use flow as a mediating variable in online learning. Third, previous research only focused on only one type of use context, such as PCs [5], mobile phones [76]. Nevertheless, the rise of the information age has given creation to a diverse media context [38]. It is worth extending the findings of previous studies to compare different media contexts in the field of online learning.

Motivated by these gaps, this research is developed based the following three questions:

Question 1: What are the antecedents of online learning satisfaction?

Question 2: What is the mechanism of flow in the establishment of online learning satisfaction?

Question 3: Does the use of context play a moderating effect in the influence mechanism of online learning satisfaction?

Subsequently, this study facilitates the development of literature on the antecedents, mediator, moderator, and outcomes of online learning satisfaction in the framework of the S-O-R model. Government, schools, platform, educators, and learners can use this as a basis to strengthen the quality of online learning and increase learner satisfaction in order to promote the development of the online learning community.

The remainder of the paper is structured as follows. In Section 2 the related literatures are reviewed. In Section 3, we construct the research model of this paper and put forward the research hypothesis based on the S-O-R framework. In Section 4, we discuss the collection of the data and sample characteristics. Section 5 presents the empirical results. Section 6 discusses the research results, and highlights the research significance and future research directions. Finally, conclusions with limitations and future direction are drawn in Section 7.

2 Literature review

2.1 Online learning satisfaction

Satisfaction is the goal pursued by products/services [77], and is a measure of user's emotions. After the user's evaluation of use, they develop an overall emotional attitude towards the product/service [14, 66]. Kotler believed that customer satisfaction refers to the customer's feelings of happiness or disappointment after using the product, which is formed by comparing the user's perceived utility after use with the expected expectations before use [39]. Martin applied the theory of satisfaction to the field of learning, suggesting that a learner is satisfied when the learning process feels greater than what was expected before formal learning, otherwise he would be unsatisfied [49]. Many scholars have conducted empirical studies on online learning satisfaction currently. Hsiu-Feng has determined the relationship among big five traits, online learning motivation and online learning satisfaction through a questionnaire survey of 153 college English learners [62]. Cong Wang found that in online learning situations, need satisfaction and need dissatisfaction have a significant impact on students' motivation and learning outcomes [70]. Online learning satisfaction is a widely recognized indicator to measure quality of teaching and learning [75]. A summary of the literature relevant to all the factors vital to the activities of online learning, and affecting learners' satisfaction with online learning is presented in Table 1. We define online learning satisfaction as experience of online learners interacting via learning products or learning services in all processes, which accumulates over time to form an overall evaluation of the product or service. Hence, we employ the online learning satisfaction as a response(R) in the current theoretical model.

2.2 Online learner factor: self-efficacy

Self-efficacy refers to the predictions and inferences made by individuals about whether they can complete a certain behavior. Self-efficacy is important because the more self-efficacious learners will make plans, seek appropriate help, and motivate themselves to immerse themselves in a learning state and potentially enhance their learning satisfaction. In Bandura's research, self-efficacy exerts its influence through four major processes of cognitive, motivational, affective, and selection [3]. Compeau defined online learning self-efficacy as the extent to which people feel confident in their ability to successfully use online learning technology to complete the learning task [27]. Liaw demonstrated that perceived satisfaction, perceived usefulness, and interactive learning environments were all found to predict perceived self-regulation in online learning [43]. High-value learning content will encourage learners to devote more learning energy to achieve better learning achievement goals, and they will be more likely to be satisfied with online learning. This study defines self-efficacy as the degree to which online learners are confident to work effectively in different characters and use self-efficacy as a stimulating(S) factor.

2.3 Educator factor: teacher's expertise

The role of teacher in online learning is different from traditional face-to-face learning. Pei-Chen Sun conducted that the existence and guidance of teachers, the ability of teachers to teach online and the flexibility of courses is an important predictor of online learning satisfaction [65]. Therefore, in addition to having knowledge of teaching, teachers are encouraged to pay attention to the topics that learners are talking about in online learning communities and can use platform learning tools to serve teaching and learning goals. Siritongthaworn conducted a survey on online learning in Thai universities and found that the key barrier was found to be student preference for instructor-led learning [63]. It is assumed that brilliant teachers' expertise focusses more on student learning and pedagogical issues and, thus, can be more flexible in adopting new approaches to promote learner flow. Specifically, the teacher's knowledge reserve, teaching level and teaching style will all affect online learning satisfaction. Therefore, this study defines teacher's expertise as online learners' perception of teachers' mastery of educational knowledge and professional knowledge, which is a stimulus(S) factor.

Table 1: Related references about online learning satisfaction

Reference	Country	Theory/Model	Methodology	Findings
Lin (2005) [45]	America	TRA, TAM and TPB	187 students in a Midwest state university to learn knowledge and skills in a physical and virtual place and analysis using SEM	Self-efficacy and technology facilitating conditions had the strongest impact on students' satisfaction
Suarez (2008)[18]	European	None	Test the acquired experience in the development and use of multimedia contents for e-learning applications	The result of the work shows the students satisfaction in the development and use of multimedia contents fore-learning applications
Pei-Chen Sun (2008)[65]	Taiwan	Six dimensions were chosen based on a comprehensive literature review.	295 data were collected and analyzed using multiple regression analysis	Earnar computer anxiety, instructor attitude toward e-Learning, e-Learning course flexibility, e-Learning course quality, perceived usefulness, perceived ease of use, and diversity in assessments are the import factors affecting learners' perceived satisfaction
Jen-Her Wu (2010)[72]	Taiwan	Social Cognitive Theory	212 data were collected and analyzed using PLS	Learning climate and performance expectations significantly affect learning satisfaction
Ke F (2013)[37]	America	The design theory of student-centered learning environment	680 respondents from 13 countries and analyzed using SEM	Learner relevance, active learning, authentic learning, learner autonomy, and computer technology competence predicted students' perceived satisfaction
Xusen Cheng (2016)[12]	China	Yield Shift Theory	113 participants were tested by experiment	Satisfaction is higher in online collaborative learning
HueiChuaWei (2020)[72]	Taiwan	None	356 students were gathered and analyzed using SEM.	Self-efficacy for online learning readiness had a mediated effect on online learning perceptions and online discussion score effect on online learning perceptions and satisfaction
Haozhe Jiang (2020)[34]	China	TSM	928 students were gathered, analyzed using SEM and the Rasch model	Self-efficacy and the perceived ease of use and usefulness of the platforms is directly and indirectly impacted by Chinese university students' satisfaction with online learning platforms
Nam-Hyun Um (2021)[68]	South Korea	None	236 students were gathered and analysis using SEM	Students' satisfaction with online learning was positively related to interactions, teaching presence, self-management of learning, and academic self-efficacy

2.4 Platform factors: platform quality and social interaction

Online learning is different from traditional classroom learning, which can carry out multiple combined learning modes in space and time dimensions. Sevgi Ozkan analyzed actual cases and showed that good platform quality could allow school learners to enjoy better learning experiences and enhancing online learning satisfaction [55]. Shun Li and Quan Xiao pointed out that optimizing the design features of mobile applications would get a payback of higher user satisfaction [42]. Adriana-Meda UDROIU helped Romanian public institutions to improve platform quality by integrating their own resources and specific activities [67]. Fredrickson conducted a study on the factors influencing online learning satisfaction at New York University. The results show that perceived value of instruction is the most important reflector of online learning satisfaction. This value is reflected in online discussions, the interaction between learners and teachers, and the interaction between learners [22]. Thus, the learning platform should pay attention to the construction of social interaction, as learners can not only interact with teachers through the platform, but also exchange learning opportunities with friends in different fields, high-quality and high-frequency social interaction has a driving effect on online learning satisfaction. Based on existing literature, it is believed that platform quality refers to the ease of use of the platform perceived by online learners and the degree to which it supports teaching. Social interaction is defined as an online learning process in which individual users or groups of users interact with each other by acquiring information and sharing experiences. Also, platform quality and social interaction are social stimuli(S) factors.

2.5 Mediating role of flow

Flow, also known as "fluid experience", is a concept first proposed by American psychologist Mihaly Csikszentmihalyi in 1975. It refers to people's interest in a challenging activity and a task driven by internal motivation [15]. Csikszentmihalyi constructed a model of the interaction between psychological factors and situational factors, which promoted the formation of flow theory. This theory has been applied in various research fields. Australian scholar Jackson conducted research on flow for outstanding athletes in the field of sports. He believed that flow was the feelings obtained during sports [33]. Hoffman and Novak applied the concept of flow experience to network navigation behavior for the first time, and defined immersion in network navigation as: a series of non-stop and seamless responses caused by human-computer interaction, truly enjoyable, accompanied by selflessness, and the state of motivation [53]. Based on these studies, this study defines flow as a positive emotion that individuals have a strong sense of participation in the process of activities, which can promote the individual to devote themselves to learning activities. At the same time, our study focuses on the mediating role of flow. The theoretical basis for the mediation role is provided by the S-O-R. model. This model theorizes that self-efficacy, teacher's expertise, platform quality and social interaction (S) create a flow state (O) which further triggers the online learning satisfaction (R).

2.6 Moderating role of use contexts

With the progress of society and economic development, in addition to the electronic information that needs to be organized and managed in personal computers at personal fixed offices and learning locations, personal mobile terminal devices such as Pad and smartphones have also become a new base for the collection, storage and use of personal information [4]. Among them, smartphones are undoubtedly becoming an important tool for personal online learning. David Mutambara discovered through the technology acceptance model that mobile learning can be used to alleviate the challenges faced by STEM education in rural areas [52]. Lee regards mobile learning as the evolution of online learning, in which mobile devices and wireless connections replace elements such as fixed computers and wired networks [41]. This paper takes use contexts as a moderating variable, and divides use contexts into two groups: Mobile context and PC context.

2.7 The S-O-R framework

The S-O-R framework involves three components: stimulus, organism, and response [50]. The S-O-R model explains that various environmental aspects can act as a stimulus (S) that influences an individual's internal state (O), which subsequently derives the individual's behavioral response (R). The model explicates how stimuli in the outer environment can fortify the inner states of individuals [20]. Many researchers have applied the S-O-R model to the field of online learning [23]. Xuesong Zhai focused on how privacy concern developed knowledge hiding perceptions of the learners, thereby affecting their online collaboration based on the S-O-R paradigm [79]. Buxbaum examined students' learning flow experiences and other personality traits using the S-O-R model [7]. As the global COVID-19 pandemic spreads, many students began to transform from offline classroom to online classroom, the sudden change in the learning environment forced students to experiment with multimedia tools for learning [80]. The flow changes may induce students to have different learning styles and online learning satisfaction. Thus, it is necessary to utilize the S-O-R model to further explore the antecedents of online learning satisfaction. More specifically, self-efficacy, teacher's expertise, platform quality and social interaction are important stimuli (S) that help create flow in students' online learning (O) to enhance the online learning satisfaction (R).

3 Research model and hypotheses

Drawing on the related studies, we proposed a conceptual model as shown in Fig.1, which presents the relationships among self-efficacy, teacher's expertise, platform quality, social interaction, flow, online learning satisfaction and use contexts.

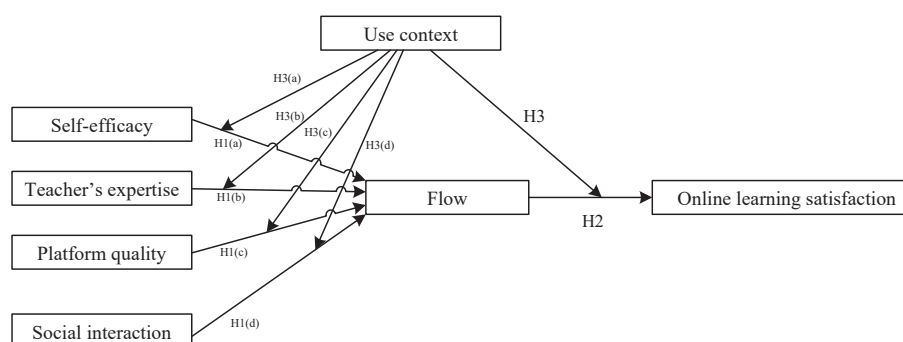


Figure 1: Conceptual model

In terms of the antecedent variables of flow, prior studies have shown that self-efficacy significantly impacts learners on learning satisfaction within an online environment [11], and literature also suggests that expert teachers are more flexible with new methods and focus more on student learning [29]. Teachers with expertise are more likely to succeed in high-satisfaction classrooms [35]. As online learning is dependent on the technology platform, the smoothness and clarity of which has an impact on the flow and learning satisfaction [13]. On the other hand, social interaction provides learners with a unique collaborative and social experience, which may raise learning satisfaction. Riva suggests that the more interactive users feel, the more immersed they will be in the virtual environment [58]. Considering all above mentioned, we have the following hypotheses:

- H1 (a): Self-efficacy positively affects flow.
- H1 (b): Teacher's expertise positively affects flow.
- H1 (c): Platform quality positively affects flow.
- H1 (d): Social interaction positively affects flow.

Flow is often described as the best state of excitement that occurs when people are fully involved in an activity [40]. Because flow brings happiness to the learning activity itself, it can internally encourage online individuals to feel more attractive to the virtual environment, or to form an emotional attitude towards the virtual environment [31]. Greater attractiveness and positive emotional state will increase learner satisfaction. Thus, we suggest the following hypothesis:

H2: Flow positively affects online learning satisfaction.

Previous research has indicated that LMS quality attributes have different impacts on students' satisfaction in the Mobile context from the PC context [13]. More specifically, learner experience of online learning can vary from Mobile context to PC context. Hence, this article divides use contexts into two groups- Mobile context and PC context. We test each path in the model in different contexts, focusing on whether the effects under different contexts are different. Hence, the following hypotheses are developed:

H3: Use context moderates the relationship between flow and online learning satisfaction.

H3 (a): Use context moderates the relationship between self-efficacy and online learning satisfaction.

H3 (b): Use context moderates the relationship between teacher's expertise and online learning satisfaction.

H3 (c): Use context moderates the relationship between platform quality and online learning satisfaction.

H3 (d): Use context moderates the relationship between social interaction and online learning satisfaction.

4 Research methodology

4.1 Questionnaire design and measurement

All measurement items from existing instruments were adapted to the context of online learning to ensure content validity. A total of 23 items associated with the constructs were included in the initial questionnaire. The initial scales in English were translated into Chinese by using the traditional back-translation method. Each item was measured with seven-point Likert scale (1= point strongly disagree, 7= points strongly agree) [44]. All items of scales are shown in Table 2.

4.2 Data collection

This study takes learners who have participated in online learning as the survey objects. The online survey was conducted through the professional survey platform "wjx.com", via its sample service. The questionnaire clearly states that only users who have taken part in the online learning can participate. In addition, we ensured that the responses were confidential.

A total of 428 online questionnaires were collected through online questionnaire survey. All returned questionnaires were carefully examined. After removing 25 careless and invalid questionnaires, and 70 questionnaires that are unclear about the context of use, a total of 333 valid questionnaires are obtained for the empirical analysis. The ages of the respondents are mainly between 16 and 40 years old. In terms of gender, there are 182 females (54.7%) and 151 males (45.3%). Most respondents have more than one year of online learning experience, and 175 people use Mobile devices to learn, accounting for 52.6% while 158 people learn on PC, accounting for 47.4%.

5 Results

5.1 Measurement model

In data analysis, we used partial least squares (Smart PLS3.0), a variance-based latent variable structural equation modeling (SEM) technique [24, 74]. In order to ensure the consistency of the latent variables in the model construction, the reliability and validity of survey data are tested first. Prior to evaluating the research model, we conducted several analyses to ensure that the latent constructs exhibited validity and reliability. Reliability results are given in Table 3.

In terms of construct validity test, this study conducted two tests: convergent validity and discriminative validity. If the factor load of the indicator variable is greater than 0.5, $AVE > 0.5$, and $reliability > 0.7$, it means that it has convergence validity [2]. As shown in Table 3, CR values are all above 0.7, and all values of Cronbach's α coefficient are also above 0.7, indicating an adequate

Table 2: Structure and source of questionnaire

Construct	Measurement items	Reference
SE	<ol style="list-style-type: none"> 1. I feel confident of using the online learning platform. 2. I feel confident of searching information on the online learning platform. 3. I feel confident of reading others' messages on the online learning platform. 4. I feel confident of providing information or respond to someone else on the online learning platform. 	Kao, Wu, and Tsai (2011); Chen et al. (2001)[9, 36] .
TE	<ol style="list-style-type: none"> 1. The teacher is knowledgeable enough about content. 2. The teacher follows up student problems and tries to find out solution via the online learning platform. 3. The teacher is proficient with all content used in the course. 4. The teacher is good at communication with students within the online learning platform. 	Ozkan& Koseler (2009); Yoon (2006)[55, 78].
PQ	<ol style="list-style-type: none"> 1. The graphical user interface of the online learning platform is suitable for online learning. 2. I have not faced any system errors on the online learning platform. 3. In the online learning platform I can easily navigate where I want. 4. I can find required information easily on the online learning platform. 5. Help option is available on the system. 	Ozkan& Koseler (2009); Hassanzadeh et al. (2012)[25, 55].
SI	<ol style="list-style-type: none"> 1. The interaction with the classmates increase my interest in the online course. 2. The interaction with the classmates helps me answer questions raised in course activities. 3. The interaction with the classmates helps me construct explanations/ solutions. 	Diep et al. (2017); Arbaugh et al. (2008)[1, 17].
FL	<ol style="list-style-type: none"> 1. I have (at some items) experienced 'flow' on the online learning platform. 2. In general, how frequently would you say you have experienced flow when you use the online learning platform? 3. Most of time when I use the online learning platform, I feel that I am in flow. 	Rodriguez-Ardura& Meseguer-Artola (2016)[59].
OLS	<ol style="list-style-type: none"> 1. I developed knowledge and competencies within the online learning platform. 2. The courses in online learning platform were a good fit for the way I like to learn. 3. The online learning platform met my expectations for what I had hoped to learn. 4. The knowledge and competencies taught through the online learning platform are personally meaningful and important to me 	Lin (2005); Wu et al. (2010)[45, 75].
<p>Note1:SE= Self-efficacy;TE= Teacher's expertise;PQ= Platform quality; SI= Social interaction;FL=Flow;OLS= Online learning satisfaction</p>		

Table 3: Assessment of the measurement model

Construct	No. of item	Mean (SD)	Cronbach 's α	AVE	CR
SE	4	4.195(1.221)	0.916	0.798	0.941
TE	4	4.289(1.329)	0.933	0.833	0.952
PQ	5	4.225(0.923)	0.788	0.540	0.854
SI	3	4.150 (1.241)	0.871	0.794	0.921
FL	3	4.520(1.245)	0.882	0.809	0.927
OLS	4	4.436(1.255)	0.938	0.842	0.955

Note1:SE= Self-efficacy;TE= Teacher's expertise;PQ= Platform quality;
SI= Social interaction;FL=Flow;OLS= Online learning satisfaction

Table 4: Discriminant validity (intercorrelations) of variable constructs

variables	SE	TE	PQ	SI	FL	OLS
SE	0.894					
TE	0.280	0.913				
PQ	0.170	0.249	0.735			
SI	0.281	0.275	0.479	0.891		
FL	0.298	0.480	0.366	0.345	0.900	
OLS	0.254	0.289	0.258	0.186	0.537	0.918

Note1:SE= Self-efficacy;TE= Teacher's expertise;PQ= Platform quality;
SI= Social interaction;FL=Flow;OLS= Online learning satisfaction

consistency reliability. Moreover, the average variance (AVE) ranged from 0.540 to 0.842, which is higher than the suggested threshold value of 0.5. This shows sufficient convergent validity.

We evaluated the square root of the AVE and structural dependence to test the discriminant validity. Fornell et al. suggested that it can be tested by testing the magnitude of AVE value of the latent variable and comparing the square root of the AVE of the latent variable with the correlation coefficient of other latent variables [21]. That is, when AVE value of the latent variable is greater than 0.5 and the square root of AVE value is greater than the correlation coefficient with other latent variables, it shows that it has good discrimination validity. It can be seen from Table 4 that all latent variables meet the conditions, so the discriminative validity of the measurement model also passes the test.

We verified the effectiveness of convergence by extracting the factors and cross-loads of all index items to their respective potential structures [18]. As shown in Table 5, all items show a high load for their relevant factors, but a low crossover load for other factors, which confirm the convergent validity of these indicators as representing distinct latent constructs.

5.2 Structural model

The results of the path coefficients and the corresponding significance levels for testing the structural model are shown in Fig.2.

As is indicated, self-efficacy (beta=0.135, $p < 0.05$), teacher's expertise (beta=0.398, $p < 0.001$); platform quality (beta=0.246, $p < 0.001$) and social interaction (beta=0.090, $p < 0.05$) are strong predictors of flow, accounting for 32.5 percent of variance in flow ($R^2 = 0.325$). As we hypothesized that self-efficacy (H1a) and teacher's expertise (H1b), platform quality (H1c) and social interaction (H1d) would positively affect flow, hypotheses H1 (a), H1 (b), H1 (c) and H1 (d) are supported. Meanwhile, flow is found positively affecting online learning satisfaction (beta = 0.583, $p < 0.001$) and explains 28.8 percent of variance in online learning satisfaction ($R^2 = 0.288$). Thus, H2 is supported.

Table 5: Factor loadings (bolded) and cross loadings

	SE	TE	PQ	SI	FL	OLS
FL1	0.283	0.402	0.360	0.350	0.896	0.484
FL2	0.257	0.418	0.284	0.277	0.902	0.459
FL3	0.264	0.474	0.340	0.302	0.902	0.503
OLS1	0.173	0.209	0.215	0.109	0.406	0.910
OLS2	0.261	0.224	0.226	0.138	0.461	0.917
OLS3	0.239	0.289	0.249	0.207	0.474	0.93
OLS4	0.248	0.318	0.249	0.209	0.591	0.914
PQ1	0.091	0.155	0.735	0.196	0.248	0.262
PQ2	-0.030	0.093	0.696	0.158	0.216	0.148
PQ3	0.140	0.233	0.728	0.194	0.314	0.202
PQ4	0.255	0.234	0.767	0.617	0.263	0.166
PQ5	0.136	0.176	0.745	0.566	0.283	0.167
SE1	0.883	0.236	0.155	0.199	0.255	0.256
SE2	0.905	0.274	0.154	0.252	0.267	0.201
SE3	0.918	0.295	0.208	0.343	0.314	0.239
SE4	0.868	0.173	0.064	0.180	0.211	0.209
SI1	0.224	0.173	0.439	0.857	0.256	0.131
SI2	0.250	0.243	0.392	0.914	0.323	0.199
SI3	0.272	0.304	0.453	0.902	0.335	0.162
TE1	0.327	0.903	0.211	0.244	0.450	0.249
TE2	0.223	0.918	0.216	0.248	0.463	0.283
TE3	0.206	0.922	0.247	0.247	0.414	0.230
TE4	0.264	0.909	0.239	0.265	0.422	0.293

Note1:SE= Self-efficacy;TE= Teacher's expertise;PQ= Platform quality;
SI= Social interaction;FL=Flow;OLS= Online learning satisfaction

5.3 Mediating effect tests

In management research, exploring research questions related to mediation has implications for understanding the drivers of success or failure of certain processes or factors [26]. We use the bootstrapping method proposed by Preacher to conduct the mediation analysis [56]. The results showed (Table 6) that the 95% confidence interval for each mediating effect did not contain 0, indicating that the indirect effects were all significantly different from 0. Hence, the mediation effects of flow were significant.

5.4 Multi-group analysis

The structural model was further compared between the two use contexts (Mobile context and PC context) using multi-group permutation tests. For hypothesis testing, it is to test whether there are differences between path coefficients. The key lies in the construction of test statistics, the core of which is the mathematical expectation and variance of the variables to obtain the t-value.

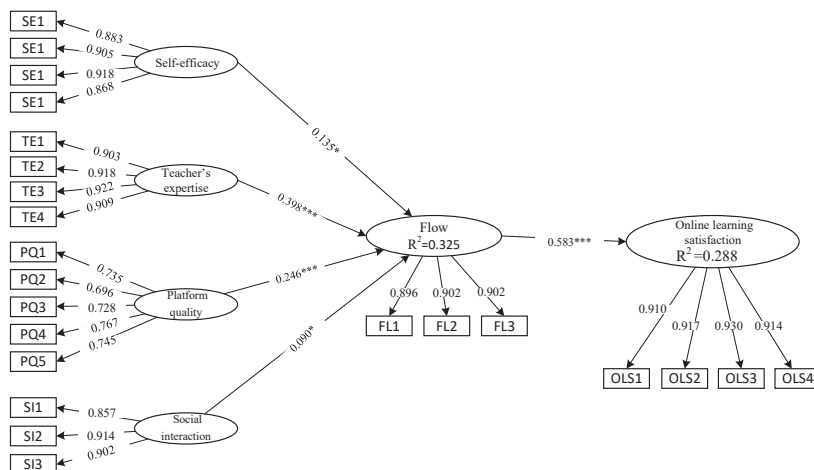


Figure 2: PLS analysis of research model

Table 6: Mediating test results

Hypotheses	Parameters	Estimated	T-values	95% CI	Decision
H2a	SE -> FL ->OLS	0.070*	2.281	[0.014,0.134]	Supported
H2b	TE -> FL -> OLS	0.195***	6.145	[0.133,0.257]	Supported
H2c	PQ-> FL-> OLS	0.107***	3.563	[0.014,0.134]	Supported
H2d	SI -> FL-> OLS	0.061*	1.919	[0.002,0.123]	Supported

Note1: Path Coefficients: *p-value< 0.05; ** p-value< 0.01; *** p-value< 0.001
 Note2: SE= Self-efficacy;TE= Teacher’s expertise;PQ= Platform quality;
 SI= Social interaction;FL=Flow;OLS= Online learning satisfaction

Table 7: Multi-group analysis result

Path	Coefficient (Standard error)		t-values	Difference
	PC(N=158)	Mobile(N=175)		
SE -> FL (Mobile<PC)	0.134(0.069)	0.126(0.091)	0.90	N
TE -> FL(Mobile<PC)	0.386(0.069)	0.347(0.080)	4.74***	Y
PQ-> FL (Mobile >PC)	0.161(0.082)	0.223(0.069)	-7.49***	Y
SI -> FL(Mobile<PC)	0.165(0.089)	0.087(0.077)	8.57***	Y
FL-> OLS (Mobile <PC)	0.573(0.052)	0.514(0.056)	9.93***	Y

Note1: *p-value< 0.05; ** p-value< 0.01; *** p-value< 0.001; Y=Yes, N=No.
 Note2: SE= Self-efficacy;TE= Teacher’s expertise;PQ= Platform quality;
 SI= Social interaction;FL=Flow;OLS= Online learning satisfaction.

Use the following formula to calculate the t-value.

$$S_{pooled} = \sqrt{\frac{N_1 - 1}{N_1 + N_2 - 2} \times SE_1^2 + \frac{N_2 - 1}{N_1 + N_2 - 2} \times SE_2^2} \tag{1}$$

$$t = \frac{PC - Mobile}{S_{pooled} \times \sqrt{\frac{1}{N_1} + \frac{1}{N_2}}} \tag{2}$$

S_{pooled} is pooled estimator for the variance; t is t-statistic with $(N_1 + N_2 - 2)$ degree of freedom; N_i is sample size of dataset for group i; SE_i is standard error of path in structural model of group i; PC and Mobile is path coefficient in structural model of group i.

It can be seen from Table 7 that there is a significant moderating effect of the use contexts on the four path relationships (Flow-Online Learning Satisfaction, Platform Quality-Flow, Social Interaction-Flow, Teacher’s expertise -Flow) in the model. More specifically, the degree of influence of flow on online learning satisfaction is significantly different under two groups. In the PC context, a more fixed learning medium can eliminate more interference, and the learner’s ability to concentrate may be higher. Therefore, flow has a significant impact on online learning satisfaction. In contrast, in the case of Mobile context, small size of the screen does not facilitate learning and the learner’s attention is easily distracted, making the impact of flow on online learning satisfaction less than on the PC context. At the same time, in the influence of teacher’s expertise and social interaction on flow, use contexts have a significant moderation effect. The path coefficient under the PC context is greater. In the past two years, the application of Mobile in learning has developed fast. Mahmoud designed an e-learning content model system based on mobile technology architecture [48]. In the context of Mobile, platform quality has a much greater impact on flow than in the PC context. In conclusion, H3, H3 (b), H3 (c), H3 (d) are all confirmed. However, there is no significant difference in the influence of self-efficacy on the flow in the two contexts, thereby rejecting H3(a).

6 Discussion and implication

6.1 Discussion

Based on the S-O-R paradigm, self-efficacy, teacher's expertise, platform quality and social interaction are studied as environmental stimulus that develops flow as an organism, and further influence online learning satisfaction as a response. The moderating effect of use contexts is also investigated. Specifically, self-efficacy is an important determinate in flow, which has a significant indirect effect upon online learning satisfaction, and this is consistent with prior studies such as Wang and Newlin [71]. The results show that learners with a high sense of self-efficacy are more confident in completing online learning activities and have significantly better flow and higher online learning satisfaction. Similarly, teacher's expertise affects the effectiveness and satisfaction of students' learning activities, which is consistent with earlier studies [19, 30]. In addition, social interaction has a significant effect on online learning satisfaction. Therefore, online learning satisfaction will increase if the teacher's timely assistance encourages learners to continue learning and the platform is responsive to students' needs and problems. Platform quality positively contributes to online learning satisfaction, and flow mediates the relationship between them. The study indicates good quality online learning courses help learners to effectively motivate continuous online learning, enhance flow and increase satisfaction. In summary, flow is an important mediator linking the four antecedents and online learning satisfaction.

The study demonstrates that use context moderates the positive relationship between flow and online learning satisfaction, and teacher's expertise and online learning satisfaction through flow, social interaction, and online learning satisfaction through flow. The learner is the center and subject of online learning. Due to the large PC screen and richer features learners tend to experience better flow in the PC context. Additionally, significant differences in the effect of teacher's expertise on online learning satisfaction exist between the two groups. Teacher's expertise has a greater impact on online learning satisfaction in the PC context than in the Mobile context. A possible explanation is that most learners choose online courses to "increase knowledge" and "learn skills", where teacher's expertise prepares learners well for teaching [6]. With richer and more powerful learning resources on PC, the teacher's expertise on PC not only meets the basic need for content mastery, but also increases online learning satisfaction. The social interaction has a greater impact on satisfaction in the Mobile context than in the PC context. Probably because it is easier to achieve content interaction, teacher interaction, learner interaction and human-computer interaction in the PC context. A step further, online learning needs to enhance and improve the interactive learning experience of learners in terms of interface design, platform quality and other instrumental support dimensions in PC to attract more learners to actively participate in online courses [60]. However, we have also found a moderating role of use context between self-efficacy and flow not supported. Probably because self-efficacy is more subjective and directly affects flow independent of the external context.

6.2 Implication

This research has enriched relevant research in the field of online learning, and has wealth value and significance in both theory and practice. In terms of theory, this paper enriches and validates the S-O-R model. The findings promote the development of literature on exploring the antecedents, mediating effect, moderating effect, toward online learning satisfaction based on the framework of the S-O-R model. This study contributes to literature by investigating the antecedents of online learning satisfaction from the three levels of learners, educators, and platforms. The four factors (self-efficacy, teacher's expertise, platform quality and social interaction) play a vital role in the development of flow of learners and as responses affect online learning satisfaction. Besides the direct effect, our study highlights the mediation effect of flow. The findings suggest that gaining a compelling flow is critical for learners to enhancing online learning satisfaction. The flow and evaluating its essential impacts in online learning context are of significance. This could encourage future researchers to develop the concept of flow in different contexts in educational backgrounds and non-educational environments. Finally, our study presents new theoretical knowledge and provides a model that can systematically compare the effects of antecedents on online learning satisfaction between Mobile

context and PC context. This argument points to a theoretical gap in the research so far. The changes of the path coefficients of the model and the significance verification under the two groups are tested respectively, which imply that the influences of teacher's expertise and social interaction on flow among PC context are greater than Mobile context, whereas the effect of platform quality on flow among Mobile context is lower than PC context. On the other hand, the influence of flow on online learning satisfaction among PC context is greater than Mobile context.

In terms of practice, for platforms that provide online education services, it is essential to understand the factors that affect users' online learning satisfaction. Studies have shown that students are willing to use VR technology for long hours of online learning [69]. Applying new technologies to the field of online learning fundamentally enhance the quality of online learning platform development. Meanwhile, learner's reviews and comments posted during social interaction are important information [10]. The platforms extract implicit preferences and emotions about product or service characteristics through social interaction [47], thereby attracting users to retain and improving user stickiness. For educators, the continuous renewal of teaching methods brings new opportunities and challenges, but the professional level and teaching quality of teachers have always been the most important factors affecting learner satisfaction. Furthermore, educators may incorporate soft skills into education to equip learners with skills, habits, attitudes, knowledge, and concepts for personal use [54]. Lastly, educators and the platform are appropriately linked to jointly do the community function of online learning, increase teacher-student and student-student interaction, and strengthen the feedback mechanism. For users, understanding the influencing factors that drive their online learning satisfaction can more clearly recognize their requirements, to choose online learning services that more closely match their own needs.

7 Conclusion

For improving the quality of online education services, improving the teaching quality evaluation system, and enhancing flow experience of learners, it is necessary to explore the antecedents of online learning satisfaction to help learners achieve better experiences. To investigate this issue, our research provides substantial theoretical contributions to the literature and inspiring managerial implications for practitioners. Firstly, we empirically examine the effects of self-efficacy, teacher's expertise, platform quality and social interaction motivations on online learning satisfaction based on the S-O-R framework to explore the antecedents of online learning satisfaction. Secondly, the paper shows that the impacts of self-efficacy, teacher experience, platform quality, and social interaction on flow are significant. Likewise, the impact of flow on online learning satisfaction is significant, which suggests flow has an important role in building learners' online learning satisfaction. Furthermore, this study contributes to existing literature by assessing the differences between two types of use contexts (i.e., Mobile and PC). Findings suggest that the influences of teacher's expertise and social interaction on flow among PC context are greater than Mobile context. Similarly, the influence of flow on online learning satisfaction among PC context is greater than Mobile context. However, the effect of platform quality on flow is lower for PC context than Mobile context. These findings are useful as we deepen the understanding of what antecedents and how they may affect online learning satisfaction.

Though the present research has certain uniqueness in terms of perspective and method, and offers theoretical and practical implications, there also has certain limitations, which provides a possible direction for the further study. First, considering the generalization of the research conclusions, the sample size can be expanded to improve the randomness and universality in coming future research. Second, because this study is conducted in China, we cannot directly generalize our findings to other countries, although online learning has been implemented by schools all around the world during the COVID-19 pandemic. Finally, the current study examines the role of flow and use contexts on online learning satisfaction, other mediators and moderators are not examined. The future research is expected to consider additional moderating (such as age and education level) and other mediating factors (such as ease of use and learner's perception of achievement).

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