Influencing Factors of Mobile Learning Interactive Behavior: Moderated Mediating Effect

Jieya Huang and Haojun Li

***Abstract*—Using interactive behavior to improve the efficiency of mobile learning is an important measure. This research uses structural equation model to construct a mediator model that regulates mobile learning interactive behavior, and investigates the influencing factors and mechanism of mobile learning interactive learning behavior. The results of a questionnaire survey conducted on a sample of 418 undergraduate students revealed that platform functionality, self-efficacy, teacher supervision, perceived usefulness, perceived ease of use, and interactive attitude have a significant positive effect on interactive behavior; perceived ease of use influenced interaction attitude through the employment of perceived usefulness as a mediator, which in turn influenced interaction behavior; the process of perceived ease of use impacting interaction attitude is heavily influenced by teacher supervision. Therefore, mobile learning implementers can promote the interactive behavior of mobile learners by improving the ease of use and usefulness of the mobile learning platform, strengthening the role of teachers in the process of mobile learning, and creating a good mobile learning atmosphere.**

***Index Terms*—Mobile learning, interactive behavior, teacher supervision, moderated mediator.**

I. Introduction

Mobile learning is a highly integrated product of mobile network technology and education. Smart mobile devices and mobile learning platforms have reshaped traditional learning and teaching methods. More and more countries are advocating government-funded initiatives to encourage schools to include mobile technology into their normal curriculum [1]. In higher education, mobile learning is an important instructional component. With the use of the internet and technological advancements, students can learn, communicate, and share their ideas via mobile learning [2]. In the mobile learning environment, learners can access a large number of learning resources anytime and anywhere, and freely interact with teachers, peers and interfaces.

Psychologist Fazio *et al*. proposed the Belief-Attitude-Behavior theoretical chain, which explains how members of society perceive something or event in any given situation and explains that the inner beliefs and others generated from whether they decide to use are the main reference indicators of attitudes, the above beliefs and attitudes ultimately affect the behavior [3]. In the process of mobile learning, factors such as the interactive functions and operations of the learning platform will prompt learners to generate meaningful beliefs about behavior development and change their attitudes towards learning, and ultimately promote mobile learning behavior. This theory is used by many researchers to investigate the factors that influence users' behavior after using the platform. The carrying out of interactive behavior in mobile learning is an important way for learners' knowledge internalization and learners can interact with peers, teachers, resources, platforms, and others in the process of completing mobile learning activities with the help of platforms.

The perception of complexity when learners use mobile technology is referred to as mobile ease of use [4]. Learners' mobile learning attitude will be more positive if they feel that it is easy to use a specific technology or system. In the study of mobile platform usage behavior, the researchers found that if users consider the platform to be easier to use, their perceived usefulness increase accordingly [5]. Based on the findings, the perceived ease of use not only can directly affect the interactive attitude, but also affect the perceived usefulness. The perceived usefulness of mobile learning refers to the feeling that learners think they can use independently in the process of using mobile platform technology, and refers to the subjective feeling that users think their work performance can be improved when using a specific system [4]. Researchers have found that perceived usefulness can directly affect mobile social knowledge sharing attitudes, and act as an mediator to improve the relationship between users' perceived ease of use and attitudes towards using [6]. In short, perceived usefulness can directly affect learners' interactive attitudes when using mobile learning platforms, and it also serves as a mediator in the association between perceived ease of use and interactive attitudes.

The highest level of platform design influencing the mobile learning process is students' non-conscious of the presence of the media. Therefore, platform functionality is an important factor in students' feelings of ease when using mobile learning platforms. Some researchers design a new mobile education platform, which can improve students' learning interest and improve students' ability to study on their own [7]. Learners' self-efficacy plays a positive role in learning, behavior and motivation. If learners have confidence in using the platform and believe that the platform is practical, they will further develop the interactive behavior in mobile learning [8].

Teacher-student interaction runs through the teaching activities. When learners use the platform for mobile learning, they also need teacher supervision, teacher design, teacher

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guidance, etc., and their interaction will be affected by teachers' support, gender differences and other factors. The meaningful mental set generated by learners in the mobile learning process, such as perceived usefulness and perceived ease of use, will also change due to teacher supervision. Studies have found that teachers' teaching, and guidance behaviors and knowledge presentation methods will effectively affect Learners' interaction [9].

Although the above researchers have shown that learners can benefit from interacting with peers, teachers, platform resources, etc. The existing research on influencing factors and mechanism of mobile learning interactive behavior need to be further developed. This study uses moderated mediator to expand previous research.

II. Materials and Methods

A. Research Hypothesis and Model

From the standpoint of the Belief-Attitude-Behavior theory chain, this research analyzes the influence of belief and interactive attitude on interactive behavior and examines the impact of platform functionality, self-efficacy, perceived ease of use, perceived usefulness, and learners' beliefs, on interactive attitudes and behaviors. Based on previous research and theoretical models, the following hypotheses are finally put forward:

H1: Mobile learning interactive attitude has a considerable (positive) impact on interaction behavior.

H2: The perceived ease of use of mobile learning has a considerable (positive) impact on interactive attitude.

H3: The perceived ease of use of mobile learning has a considerable (positive) impact on perceived usefulness.

H4: The perceived usefulness of mobile learning has a considerable (positive) effect on interactive attitude.

H4-1: The influence of perceived ease of use on interactive attitude is mediated by the perceived usefulness of mobile learning.

H5: The functionality of mobile learning platforms has a considerable (positive) effect on perceived ease of use.

H6: Learners' self-efficacy has a considerable (positive) effect on perceived usefulness.

H7: The relationship between perceived ease of use and perceived usefulness is moderated by teacher supervision.

According to the assumptions stated above, this research constructs a moderated mediating hypothesis model(see Fig. 1) with mobile learning interactive behavior as the dependent variable, perceived usefulness as the intervening variable, and teacher supervision as the adjustment variable from the perspectives of behavior, attitude and belief using the Belief-Attitude-Behavior theoretical chain.

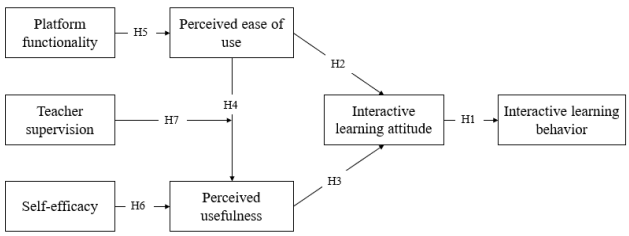

Fig. 1. Influencing factors of mobile learning interactive behavior model.

B. Research Object

The research is conducted after university students completed the mobile learning courses. The original data was evaluated and screened after 467 questionnaires were gathered. This study has got rid of invalid questionnaires with the answering time less than 100 seconds or all the answers were same and processed outliers. Finally, 418 valid questionnaires are obtained.

C. Questionnaire Design

This study uses questionnaire survey, and the questionnaire is divided into four sections: the introduction, the demographic information of the surveyed learners, the basics of learners' mobile learning, the influencing factors of the learners' interactive behavior in the context of mobile learning. The questionnaire is revised based on the reliable scales of mobile learning interactive behavior and real situation. Other variables are scored using the 5-point Likert scale, which are in the order of complete agreement, basic agreement, general agreement, not very agreement, and complete disagreement. Each respondent needs to fill in the answers according to their subjective feelings and scores are 5, 4, 3, 2 and 1 respectively. Finally, Questionnaire on Influencing Factors of Mobile Learning Interactive Behavior is formed.

D. Statistical Analysis Methods

This study builds a structural equation model on the influencing elements of mobile learning interactive behavior using SPSS 25.0 and AMOS 22.0, and explores the influencing factors of mobile learning interactive behavior and its mechanism of action. Perceived usefulness as mediating effect is tested by Bootstrap Method and teacher supervision as regulatory effect is analyzed by latent moderatored structure model.

III. Results

A. Evaluation on Reliability and Validity

To test the internal consistency of Questionnaire on Influencing Factors of Mobile Learning Interactive Behavior, Fornell believed that the AVE value of the latent variable is above 0.5 to have good convergent validity [10]. In addition, this study analyzed the convergent validity and discriminant validity of the questionnaire. In terms of convergent validity, the indicators of latent variables are shown in Table I. In Table I, Unstd represents the unstandardized coefficients, S.E. represents the standard error, Z value represents the critical ratio, P represents the significance level(P=*** means that P<0.001), Std represents the standard factor loading, SMC represents the square multiple correlations, CR represents the composite reliability, AVE represents the average of variance extracted, and the second column indicates the different questions under latent variables. Each item has a factor loading larger than 0.6, and the AVE value is greater than 0.5. Therefore, the questionnaire has good convergent validity (see Table 2, M represents average value, SD represents standard deviation, IB represents interactive behavior, AT represents interactive attitude, PE represents

perceived ease of use, PU represents perceived usefulness, SE represents self-efficacy, PC represents platform functionality, TA represents teacher supervision). The measurement model's validity is good, so the structural model can be further established.

TABLE I: THE RELIABILITY AND VALIDITY TEST OF THE MEASUREMENT MODEL

Dimension	Questions	Parametric significance estimation				Question reliability		Composite reliability	Convergent validity
		Unstd	S.E.	Z value	P	Std	SMC	CR	AVE
Interactive behavior	IB1	1				0.763	0.582	0.854	0.662
	IB2	0.994	0.062	16.147	***	0.828	0.686		
	IB3	1.051	0.065	16.273	***	0.847	0.717		
Interactive attitude	AT1	1				0.663	0.44	0.797	0.568
	AT2	1.303	0.103	12.637	***	0.779	0.607		
	AT3	1.389	0.109	12.69	***	0.811	0.658		
platform functionality	PC3	1				0.862	0.743	0.888	0.726
	PC2	1.026	0.047	21.855	***	0.862	0.743		
	PC1	0.981	0.048	20.478	***	0.831	0.691		
self-efficacy	SE3	1				0.748	0.56	0.79	0.557
	SE2	1.129	0.091	12.417	***	0.733	0.537		
	SE1	1.104	0.084	13.101	***	0.758	0.575		
Perceived usefulness	PU1	1				0.781	0.61	0.874	0.699
	PU2	1.179	0.064	18.447	***	0.854	0.729		
	PU3	1.191	0.064	18.714	***	0.871	0.759		
Perceived ease of use	PE3	1				0.819	0.671	0.844	0.643
	PE2	1.085	0.064	16.944	***	0.795	0.632		
	PE1	0.974	0.058	16.816	***	0.792	0.627		
Teacher supervision	TA1	1				0.761	0.579	0.849	0.652
	TA2	0.917	0.056	16.372	***	0.831	0.691		
	TA3	0.945	0.057	16.513	***	0.829	0.687		

B. Hypothesis Testing for Moderated Mediating Effects

Firstly, establish a measurement model and use the balance method to establish the measurement indicators of each variable, all of which are significantly high correlation, indicating that the measurement indicators can better represent the research variables. The Amos analysis results show that the measurement model fits well ($\chi 2/df$ =2.12, RMSEA = 0.052, CFI = 0.968, GFI = 0.926, IFI=0.968, TLI=0.959, $\chi 2/df$ denotes Chi-square value divided by the number of degrees of freedom, RMSEA denotes root mean square error of approximation, CFI denotes comparative fit index, GFI denotes goodness of fit index, IFI denotes incremental fit index, TLI denotes Tucker-Lewis index).

Secondly, descriptive statistical analysis and Pearson correlation analysis were conducted on interactive behavior, perceived ease of use, interactive attitude, perceived usefulness, platform functionality, self-efficacy and teacher supervision. The mean value, standard deviation and correlation matrix are shown in Table II.

The results show that there are significant correlations among interactive behavior, perceived ease of use, interactive attitude, perceived usefulness, platform functionality, self-efficacy, and teacher supervision. The specific manifestations are as follows: the correlation coefficients of perceived usefulness and perceived ease of use with interactive attitude and interactive behavior are significantly positively correlated; the perceived usefulness and perceived ease of use have a significant positive correlation, which is suitable for the subsequent mediation effect test; At the same time, the correlation between teachers' supervision and perceived usefulness, perceived ease of use is considerable and the coefficient is small, which is suitable for the subsequent regulatory effect test. Therefore, the data can be used for further moderated mediation analysis.

TABLE II: CORRELATION COEFFICIENT MATRIX FOR ESTIMATING LATENT VARIABLES

Variable name	Average value	Standard deviation	Correlation coefficient between variables						
	M	SD	IB	AT	PE	PU	SE	PC	TA
IB	3.750	0.773	1						
AT	4.027	0.660	0.532**	1					
PE	3.958	0.652	0.444**	0.507**	1				
PU	4.100	0.659	0.530**	0.535**	0.599**	1			
SE	3.905	0.709	0.251**	0.402**	0.451**	0.457**	1		
PC	3.949	0.718	0.548**	0.549**	0.583**	0.669**	0.322**	1	
TA	3.889	0.643	0.557**	0.576**	0.523**	0.567**	0.425**	0.574**	1

Note: *$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, all numbers are rounded to the nearest two decimal places, the same below.

The study constructs a mediating effect model based on perceived usefulness. To test the mediating effect of mobile

learning interactive behavior, Amos is used to construct the mediation effect model shown in Fig. 2.

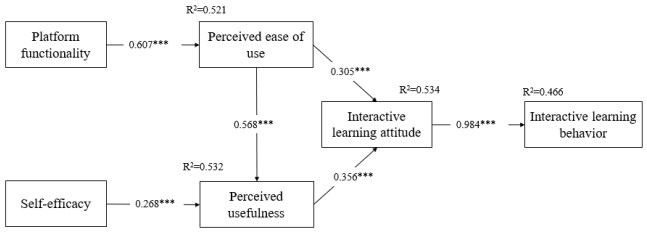

Fig. 2. A mediation effect model of mobile learning interactive behavior.

Then Bootstrap is used to test the significance of the mediating effect of perceived ease of use, and the sampling size of Bootstrap is 1000. The results (see Table III, Z means point estimate divided by standard error) show that each prediction coefficient in the model is significant (β perceived ease of use-interactive learning attitude=0.305, p<0.001; β perceived usefulness-interactive learning attitude=0.356, p<0.001, perceived ease of use-perceived usefulness-interactive learning attitude=0.202, p < 0.001 and the confidence interval is [0.098, 0.277], excluding 0). It can be concluded that when perceived ease of use affects interactive attitude, in addition to direct influence, it also affects through the intervening variable, perceived usefulness, that is, it produces partial intermediary effects, indicating that hypothesis H4-1 is true.

TABLE III: DECOMPOSITION TABLE OF TOTAL EFFECT, DIRECT EFFECT AND MEDIATING EFFECT

Effect category	Point estimate	Product of coefficients		Bootstrapping			
				Bias-Corrected 95% CI		Percentile 95% CI	
		Standard error	Z	Lower	Upper	Lower	Upper
			Total effect				
Total	0.529	0.068	7.779	0.402	0.673	0.397	0.663
			Indirect effect				
PE—PU—AT	0.173	0.044	3.932	0.098	0.277	0.09	0.277
			Direct effect				
PE—AT	0.356	0.083	4.289	0.205	0.526	0.202	0.524

TABLE IV: DECOMPOSITION TABLE OF MEDIATING EFFECTS WITH REGULATION

Path	Moderator variable				Bias-Corrected 95%CI			Percentile 95%CI		
	teacher supervision	Standard error	effect value	Mean	Lower	Upper	P	Lower	Upper	P
PE-PU-AT	M	0.031	0.139	0.138	0.086	0.211	0	0.082	0.204	0
	M-1SD	0.036	0.185	0.183	0.122	0.265	0	0.116	0.257	0
	M+1SD	0.032	0.094	0.092	0.036	0.165	0.001	0.03	0.159	0.002
	high-low	0.046	-0.091	-0.09	-0.185	-0.004	0.041	-0.184	-0.002	0.045

According to the theoretical assumptions of this study, AMOS 22.0 is used to build a research model, as shown in Fig. 3. The study uses nonparametric percentile Bootstrap method to test the mediating effect and regulatory effect, and the data are repeatedly sampled for a total of 5000 times.

To estimate the effect more accurately, this study uses the latent variable structural equation model without the mean structure for testing, and Amos is used for confirmatory factor analysis. To estimate the standardized solution of the regulatory effect, firstly convert each measurement index into a standard score, then estimate the corresponding latent variables by using the standardized measurement index to establish a measurement model. The specific inspection process is divided into three steps. First, standardize the variables contained in the four dimensions of teacher supervision, perceived usefulness, perceived ease of use, and interactive attitude; Then, construct the interactive item of teacher supervision and perceived ease of use. Lastly, construct the research model and compare the data to estimate the results. The fitting results show that each index has reached the required critical value ($\chi 2/df$ = 2.635, RMSEA = 0.036, CFI = 0.928, IFI = 0.929, TLI = 0.917), and the model fits well.

When the mediation process is regulated, it is necessary to test whether the mediating effect changes with the change of the moderator variable. The specific method is to take values a standard deviation above and below the mean value(M ±1SD), and compare the difference of the mediating effect value between the two groups (see Table IV). Because the non-standardized value is closer, in the high teacher supervision group, the non-standardized mediating effect value is 0.032 (p < 0.05); in the low teacher supervision group, the non-standardized mediating effect value is 0.036, which is significant compared with the mediating effect (p < 0.001), indicating that the mediating effect of perceived ease of use is mediated by the quality of teacher supervision. There is also a considerable difference in the path taken by the high teacher supervision group and the low teacher supervision group (p < 0.05), and the confidence interval [-0.185, -0.004] doesn't contain 0, the results indicates that the regulatory effect is significant, and the hypothesis H7 is true.

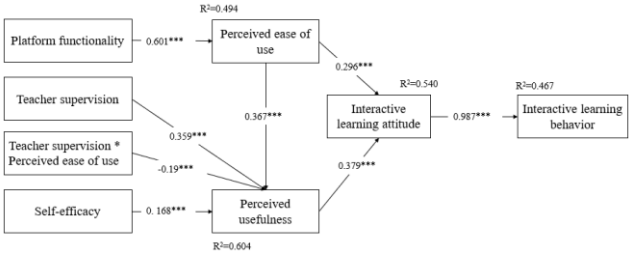

Fig. 3. A moderated mediating model of mobile learning interactive behavior.

To more intuitively analyze the nature of teacher supervision as a moderator variable, a simple slope test chart (see Fig. 4) is drawn to study the predictive effect of

perceived ease of use on mobile learning interactive attitude in the two groups. The results show that when teacher supervision is strict, the non-standardized value of the impact of perceived ease of use on interactive learning attitude is 0.092 ($p < 0.05$), and when teacher supervision is lax, the non-standardized value of the impact of perceived ease of use on interactive learning attitude is 0.185 ($p < 0.001$).

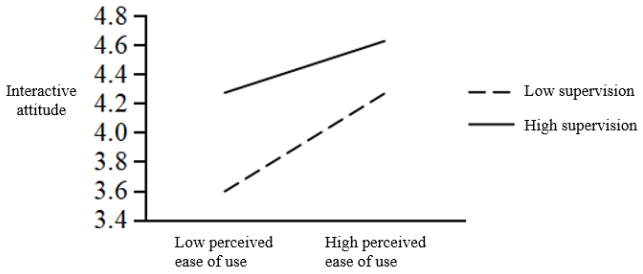

Fig. 4. The moderating role of teacher supervision on the association between perceived ease of use and mobile learning interactive attitude.

IV. Discussion

This research based on the affecting factors and mechanism of college students' mobile learning interactive behavior, explores the influence mechanism of self-efficacy, perceived ease of use, perceived usefulness, interactive attitude, mobile learning platform functionality on learners' interactive behavior, and through moderated mediation analysis to explore the relationship between teacher supervision and learners' interactive attitude and behavior.

A. The Mediating Effect of Perceived Usefulness between Perceived Ease of Use and Mobile Learning Interactive Attitude Is Significant

The results show that learners' perceived usefulness in mobile learning interaction plays a significant mediating effect between perceived ease of use and interactive attitude. If users think that a platform with easy operation and comprehensive interactive functions has high usable value, users will show a positive attitude. If users believe the platform is difficult to use and the functions are complex, this will have a negative impact on the learner's interactive attitude. Research in the field of mobile platform design also supports this view. This explains that the learner's interactive attitude will be affected by the ease of use and practicability of the mobile learning platform. Their interactive attitudes will be more positive if the learning platform's function can support learners' learning activities and make them believe that the interactive operation is straightforward and that the interactive learning behavior can assist them achieve learning objectives.

B. The Moderating Effect of Teacher Supervision on Learners' Interactive Attitude Is Significant

The study finds that teacher supervision plays a moderating role between learners' perceived usefulness and perceived ease of use, and has a has a substantial impact on interactive attitude. The results show that the stricter the teacher supervision, the weaker the effect of perceived ease of use on the interactive attitude; When the degree of teacher supervision is low, the perceived ease of use is strong, and the interactive attitude will be more positive; but if teacher doesn't participate in supervision, the perceived ease of use will be low, and the interactive attitude will be more negative. Teacher-student interaction runs through the teaching activities. When learners use the platform for mobile learning, they also need teacher supervision, design, and guidance, and learners' interaction will be affected by teachers' support, gender differences, and other factors [6]. Due to teacher supervision, learners' meaningful mental sets such as perceived ease of use and perceived usefulness will alter during the mobile learning process. Some studies have found that teachers' teaching guidance behaviors, knowledge presentation, etc. can effectively affect learners' interaction [9]. Therefore, the intervention of academic assistants and tutors has an important impact on learners' online interactive behaviors and attitudes in mobile learning.

C. Learners, Mobile Learning Platforms and Teachers Are All Expected to Participate Positively in the Mobile Learning Interaction

Learners should take a correct learning attitude and improve their interactive efficiency. When selecting courses, learners are supposed to choose those which can meet their needs and ensure that the quality of the courses can improve themselves. Actively participate in learning activities in the courses, such as instant commenting in the form of bullet chatting or discussing with peers in the discussion area on questions when watching teaching videos. To consolidate and improve after courses, it's necessary to collect and share high quality course contents.

Mobile learning platforms require consummate technical services and interactive functions. The mobile learning platform uses technologies such as big data analytics, context awareness, and personalized push to realize diversified presentation of content knowledge and highly interactive learning activities [9]. Besides, mobile learning platforms should focus on the development and design of learning resources. The length, pictures, and subtitles of micro-lessons need to match the cognitive characteristics of learners, and the content should be concise and practical so as to improve the perceived usefulness of learners.

The most important thing is that teachers should provide "supervision, guidance, promotion" and design interactive strategies. This study has found that the addition of teacher supervision has a considerable influence on learners with lower perceived ease of use, and their interactive attitudes can be significantly improved. In mobile learning, learners are the center of the whole learning activity and research has proven that it is necessary to emphasize the role of teachers in "supervision, guidance, promotion" in this process. Online learners will better understand knowledge and their mobile learning interactive enthusiasm will be improved if teachers can provide timely feedback and feasible suggestions.

In terms of the significance of this study, the factors influencing learners' interactive behavior in mobile learning include aspects such as media platform design and teacher supervision, in addition to learners' own perceptions. According to the results, this study concludes that learners' mobile learning interactive attitude is an important factor to promote interactive behavior, and in the process of

developing attitude enthusiasm, perceived usefulness has a strong mediating influence, and the moderating effect of teacher supervision should be paid attention to. Due to the complexity of the mobile learning environment, the mechanism of influencing factors needs to be continuously adjusted, and the research theories and models need to be further improved considering the actual situation. The research also has the following shortcomings: the survey sample in this study is relatively small, and the participants are only undergraduates in universities, so the data has some limitations. Secondly, it only considers the influence of platform functionality, self-efficacy, perceived usefulness, perceived ease of use, and interactive attitude on mobile learning interactive behavior, and less consideration is given to the role of peers' trust and cooperation. It is hoped that in the follow-up research, the scope of subjects can be further expanded, and the theoretical model and mechanism can be improved.

V. Conclusion

With a moderated mediating model, this research looks into the factors that influence mobile learning interactive behavior as well as the mechanisms that underpin it. The findings show that perceived usefulness mediates the relationship between perceived ease of use and interactive attitude, teacher supervision moderates the impact of perceived ease of use on perceived usefulness and significantly affects the interactive behavior, expanding the scope of existing research. To improve theoretical research, the study will add different variables like peers' trust and cooperation, and invite other mobile learners of various age stages to participate in questionnaire filling.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Haojun Li conducted the research; Jiaya Huang analyzed the data and wrote the paper; all authors had approved the final version.

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