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Influencing Factors of Preschool Teachers' Intention to Accept and Use Mobile Learning in Early Childhood Science Education: Implications on Teacher Education

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Abstract: The adoption and integration of mobile learning technology in early childhood education is a topic of increasing interest and importance. It is crucial to comprehend the factors that affect preschool teachers' intention to accept and use mobile technology. Guided by UTAUT2 as a theoretical lens, the study offered quantitative validation of core technology acceptance factors and their implications. This study investigated 272 preschool teachers in Wuyishan City of Fujian province through SPSS 22 and AMOS 22 data analysis. The results show that performance expectation, effort expectation, social influence, promotion condition, hedonic motivation and habit have significant effects on the behavioral willingness to accept mobile learning. Facilitating conditions and habit support influence usage behavior. Furthermore, learning values do not support behavioral intentions. The findings contribute empirically substantiated and context-specific insights to strengthen the foundations of technology adoption theory while also generating practical guidance to foster mobile learning in Chinese early childhood education.

Keywords: Preschool teachers, Mobile learning, Intention, UTAUT2

1. Introduction

In recent years, technology as an educational tool to teach natural sciences has been a frequent topic of discussion among teachers and educational policymakers (Kalogiannakis & Papadakis, 2017; Kalogiannakis & Papadakis, 2008). There is evidence that the use of technology has a direct positive impact on the teaching of natural sciences because it introduces educators and learners to new ideas that they cannot directly observe (Papadakis et al., 2018). Mobile learning provides an immersive experience that visually demonstrates how variables interact in scientific models, improving understanding of the topics taught (Criollo-C et al., 2020). Mobile learning refers to the learning process enabled, empowered, and enhanced by mobile devices with convenient access to suitable supporting materials; learners may enjoy a highly portable and genuinely personalized experience of learning (Quan et al., 2022). In 2013, UNESCO launched the "Mobile Learning Policy Guide", which clearly pointed out that "mobile learning, a brand-new model, has its unique advantages increasingly manifested so that both educators and learners can benefit from it" (Hai-yan & Ling, 2021).

Some researchers pointed out that the user' s attitude and acceptance of mobile learning determine whether users can experience the convenience and advantages of mobile learning and ultimately affect the use of mobile learning (Baydas & Yilmaz, 2018). This attitude will identify strengths and weaknesses and facilitate the development of technological infrastructure (Samad et al., 2021). Investigating teachers' attitudes and cognitions can help children learn how the value of technology affects their practice and the effectiveness of any technology in the classroom (Nikolopoulou, 2020). In other words, successfully integrating technology into the classroom requires a positive understanding and attitude towards this technology and a certain understanding of its benefits (Al-Jarrah et al., 2019).

However, there are very few research/review reports on preschool teachers' views on the application of mobile technology in preschool classrooms (Nikolopoulou, 2020), and there is limited empirical evidence on early preschool teachers' cognition of mobile technology learning (Nikolopoulou, 2021). Meanwhile, the relative lack of teachers' use of information technology, which adversely affects young children' s experiential learning in science (Shuzhen, 2018). In addition, the facilities provided by schools are also very limited, including lack of (or limited) resources/equipment, teacher training opportunities, and lack of funds and corresponding mobile learning resource support (Nikolopoulou, 2021). Therefore, we need to investigate teachers' attitudes and acceptance of mobile learning in order to provide education managers with what kind of support to help teachers adapt and manage tablet computers and mobile learning, as well as bring changes to their professional practice (M. Kalogiannakis & S. Papadakis, 2019; Papadakis, 2016).

Venkatesh et al. (2012) pointed out that formulating a comprehensive research framework with substance and organization is of great significance and practical significance for future research in the field of information technology. The unified theory of technology acceptance and use (UTAUT) has gained credibility in the field of mobile learning/technology (Venkataraman & Ramasamy, 2018). The Extended Unified Theory of Technology Acceptance and Use (UTAUT2) was established less than ten years ago and has received more than 6000 citations in information systems and other fields (Tamilmani et al., 2021). To explain the intention of preschool teachers to accept and use mobile learning in their science teaching practices, variables from the UTAUT2 model were included in this study and their influences were investigated.

2. Literature review

2.1. Mobile Technology Acceptance and Use Intention

Intentions are about one's own actions in specific situations and is an important building block of intentions (Schroder et al., 2014). Technology acceptance refers to a person's intention to employ technology for the tasks it is designed to support. Previous research has mainly focused on the understanding of user behavior and the direction of adoption and use of new technologies at the organizational and individual levels (Issa Alghatrifi, 2020). The researchers surveyed attitudes towards mobile learning acceptance among different groups from various industries or sectors. These groups include university students (Abdallah et al., 2021; Lai et al., 2022), Pre-service teachers (Chen & Tsai, 2021; Kuo et al., 2023), banking system (Abdou & Jasimuddin, 2020; Owusu Kwateng et al., 2019), catering industry (Palau-Saumell et al., 2019) and so on. For example, Kuo et al. (2023) investigated changes in perceptions of iPad use in instruction, and the relationship between motivation, self-efficacy, and iPad use intentions among pre-service teachers at a university in the northeastern United States. Owusu Kwateng et al. (2019) selected 300 Ghanaian mobile banking service users as the survey object.

While mobile learning has been widely used these days, investigating and acknowledging the main driving factors that increase the intention to use and adopt such a method is essential (Liu et al., 2010). Based on the research purpose, it is necessary to understand the intention of preschool teachers to use mobile learning because their intention will affect their classroom teaching practice. Hai-yan and Ling (2021) pointed out that teachers specializing in preschool education have a strong willingness to learn and a more positive attitude. Nikolopoulou (2020) thought investigating teachers' attitudes and beliefs could influence their practice, how well any technology is used in the classroom, and how well children understand the value of technology. In addition, knowledge of the factors influencing mobile technology acceptance and usage intention in specific contexts can effectively explain the critical reasons behind them. Kalogiannakis and Papadakis (2019) investigated the willingness of pre-service kindergarten teachers to use mobile devices for activities in the field of natural sciences using the use dimension of the TAM model. The research results can provide reference suggestions for educational technology system developers, preschool education managers, and policymakers. Hong et al. (2021) pointed out that technology developers should design friendly operations for preschool teachers and provide easy-to-understand instructions; preschool managers need to strengthen teacher training; policymakers need policy guarantees and support.

2.2 Theoretical Framework

2.2.1 The Extended Unified Theory of Technology Acceptance and Use (UTAUT2)

Venkatesh et al. (2003) conducted research based on previous models/theories and formed the Unified Theory of Technology Acceptance and Use (UTAUT). The theory is developed through the review and integration of the eight leading theories and models: The Theory of Planned Behaviour (TPB), Theory of Reasoned Action (TRA), Technology Acceptance Model (TAM), Combined Technology Acceptance Model and Theory of Planned Behaviourial (C-TAM-TPB), Motivational Model (MM), Model of PC Utilization (MPCU), Social Cognitive Theory (SCT), Innovation Diffusion Theory (Schmidt & Finan). UTAUT shows that the model is composed of four core factors, including performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating conditions. These four are the factors that predict user behavior intentions (Lai, 2017) and have a direct impact on behavior intentions (Barrane et al., 2018). In 2012, Venkatesh et al. (2012) proposed and tested UTAUT-2 (the extension of the Unified Theory of Acceptance and Use of Technology) to compensate for the significant factors of the consumer technology use environment. In UTAUT-2, three new structures to the UTAUT structure were added: hedonic motivation (HM), price value (PV), and habit (HB). In UTAUT2, three moderating variables of individual differences (age, gender, and experience) were cited in the structural model, mediating the impact of core variables on BI and technology use (Venkatesh et al., 2012).

2.2.2 Proposed Model and Hypotheses

UTAUT2 offers a solid theoretical foundation and is suitable for studying the adoption and use of mobile learning in educational contexts. In this study, the price value and consumption experience in the UTAUT2 original model are not suitable as variables for the intention of kindergarten teachers to accept and use mobile technology in the practical teaching of science education, and the learning value and teaching experience will be introduced into it for description. Finally, performance expectation (PE), effort expectation (EE), facilitating conditions (Conway & Huffcutt), social influence (SI), hedonic motivation (HM), learning value (LV) and habit (HT) form the influencing factors in the research hypothesis:

Performance expectancy: Reflects the perceived utility of users using mobile learning (Venkatesh et al., 2003; Venkatesh et al., 2012). Performance expectancy had an impact on the behavioral intentions of preschool teachers. This study can describe the extent to which in-service preschool teachers believe that using mobile learning will enable better teaching results in science education teaching activities.

H1. Performance expectancy (PE) has a significant positive impact on the behavioral intention (BI).

Effort expectancy: Reflects the perceived difficulty of users using mobile learning (Venkatesh et al., 2003; Venkatesh et al., 2012). In this study, the behavioral intentions of preschool teachers are affected by effortful expectations. If mobile learning is simple to understand and apply, teachers are willing to put in the effort to choose it.

H2. Effort expectancy (EE) has a significant positive impact on the behavioral intention (BI).

Social influence: Reflects the influence of group opinions on individual user behavior (Venkatesh et al., 2003; Venkatesh et al., 2012). In this study, social influence is defined as the degree to which in-service preschool teachers who use mobile learning are influenced by the feelings, thoughts, and behaviors of particular people or groups in their social environment, as well as the degree of trust they expect to have in the use of a particular technology to determine their willingness to use mobile learning.

H3. Social influence (SI) has a significant positive impact on the behavioral intention (BI) .

Facilitating conditions: Users have the resources and platforms to use mobile learning (Venkatesh et al., 2003; Venkatesh et al., 2012). For our study, the facilitation condition relates to the ease with which preschool instructors use mobile learning in terms of policy support, availability of instructional resources, payment of service fees, equipment use, etc. They might stop using mobile learning if the preschool teachers lack these conveniences.

H4. Facilitating conditions have a significant positive impact on the behavioral intention (BI).

H5. Facilitating conditions have a significant positive impact on the use behavior (UB).

Hedonic Motivation: Hedonic motivation is conceptualized as perceived enjoyment (Venkatesh et al., 2012). In the context of this study, it refers to the enjoyment/pleasure that in-service preschool teachers derive from learning using mobile learning. If employing mobile learning content makes them feel good or happy, in-service preschool teachers embrace and use it more frequently. If the mobile learning content is not enjoyable for them, they can stop utilizing it because of the bad experience.

H6. Hedonic motivation (HM) has a significant positive impact on the behavioral intention (BI).

Learning Value: It can be defined as the "perceived value for the spent time and effort" (Ain et al., 2016). It refers to the enthusiastic, lively, and joyous attitude that comes from using mobile devices in a learning environment (Sitar-Taut & Mican, 2021). From a teacher' s point of view, value is related to the content of teaching resources obtained, which determines the value.

H7. Learning value (LV) has a significant positive impact on the behavioral intention (BI).

Habit: The tendency to use a technology automatically due to learned behavior (Venkatesh et al., 2012). Habit in this study refers to how much teachers are likely to actively employ mobile learning in their scientific education lessons due to mobile learning. Venkatesh et al. described habits as having a direct effect on usage and an indirect effect through behavioral intent.

H8. Habit (HT) has a significant positive impact on the behavioral intention (BI).

H9. Habit (HT) has a significant positive impact on the use behavior (UB).

Behavioral intention: Individual's intention to use a particular technology for different tasks (Ain et al., 2016). Intention is the subjective probability that an individual will perform a specified behavior (Ajzen & Fishbein, 1975). This study uses behavioral intention as an independent variable to assess how well in-service preschool teachers are integrating mobile learning into their practices.

Use behavior: It is the result of the influence of various factors. Use behavior may not result from deliberated cognitions and are simply routinized or automatic responses (Venkatesh & Davis, 2000). The usage behavior in this study refers to the behavior of kindergarten teachers accepting and using mobile learning in science education teaching practice.

H10. Behavioral intention (BI) has a significant positive impact on the use behavior (UB).

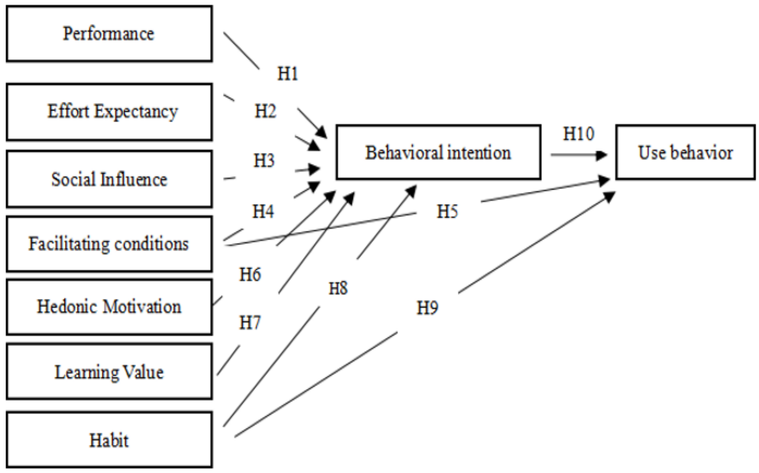

Fig. 1 Proposed Research Model

3. Methodology

3.1. The Instrument

The overall content of the questionnaire was divided into two parts. The first part was the demographic information of the respondents, including teacher age, teacher gender, and teaching experience, which are also the moderator variables in our research. The second part was the test items of the questionnaire. All questionnaire items are based on previous research. It contained 36 questions on the major constructs included in the proposed model. The original items from the UTAUT2 theoretical model of Venkatesh et al (2012). At the same time, refer to the scales compiled by Nikolopoulou et al. (2020), Ain et al. (2016), Gansser and Reich (2021), Prasetyo et al. (2021), and other researchers (Alghazi, Kamsin, et al., 2021b; Alowayr & Al-Azawei, 2021; Sitar-Taut & Mican, 2021). In addition, according to the actual situation of this research, appropriate adjustments have been made to the language expression according to the Chinese context. Finally, as the purpose of this research, five Likert scales are used to simplify the research and quantitatively describe the attitude of in-service kindergartens towards the adoption and use of mobile learning in science education. Based on the revised questionnaire, educational experts and scholars were invited to analyze and evaluate the contents of the questionnaire.

Subsequently, through a pilot test, questionnaires from 152 respondents were collected and analyzed to test the reliability and validity of the questionnaire results. The pilot test results show that the KMO and Bartlett tests are 0.9000(greater than 0.7), and the Chi-square approximation is 4327.61, $p<0.05$ indicates that the independent variable hypothesis is invalid. This indicates that the validity structure of the scale is good and can be used for further exploratory factor analysis. In addition, the results of the pilot study showed that Cronbach's α ranged from 0.724 to 0.938, and the coefficients were all above 0.7, which met the reliability test requirement, indicating that the questionnaire items utilized in this study had good measurement reliability.

3.2. Sample and Data Collection

The study method used to choose a sample group of people who reflect the population is known as sampling (Berndt, 2020; McGaghie et al., 2001). Compared to the census survey, sampling has lower time and resource consumption and quicker data gathering (Khan, 2020). If the area of interest is relatively small, obtaining a probability sample may not be a significant consideration because a complete census of the target population is possible, or certain types of purposeful sampling are better suited to the researcher's needs (Rosenbaum & Lavrakas, 1995). The research will use a purposeful sampling method to select samples. Purposeful sampling is appropriate to provide reliable and relevant information for research questions and purposes (Thomas, 2011).

The research selected the kindergarten teachers of public kindergartens in Wuyishan City, Fujian Province, southeast China, as the research sample. The purpose of this study was to understand the overall situation and influencing factors of the willingness of preschool teachers in Wuyishan City, Fujian Province to accept and adopt mobile learning. The inclusion criteria for participants in this study (i.e., early childhood teachers) were that they were active early childhood teachers in their careers and that their kindergartens provided mobile devices, wireless communication technologies, and mobile learning platforms in science education to support teaching and learning. Data collection was mainly conducted through the distribution of online questionnaires. After careful analysis and examination of the questionnaire data, some invalid questionnaires were eliminated. The survey ultimately collected 272 online questionnaires. Subsequently, SPSS 22.0 and Amos 22.0 were used to evaluate and analyze the collected data.

4. Data Analysis and Results

In this study, SPSS 22 and AMOS 22 software were used for analysis. In the data analysis, the demographic information of the participants was first given. Second, confirmatory factor analysis (CFA) was used to assess the reliability, convergent validity, and discriminant validity of the measurement model, and third, a structural model was used to test the proposed hypotheses.

4.1 Participants' Demographic Profile

In terms of the gender of early childhood teachers, 265 (97.4%) were mostly female, and only 7 (2.6%) were male. This sample group consists of many female teachers, representing the overall situation of preschool teachers in China. The age distribution was 62.1% for 21–30 years old, 32.4% for 31–40 years old, 5.5%% for 41–50 years old. The age is mainly concentrated in the 21–30-year-old stage. As for teaching experience, there are 65 people (23.9%) with 1-2 years, 24 people (8.8%) with 3 years, 4 people (8.8%) with 4 years, 75 people (27.6%) with 4 years, 84 people (30.9%) with 4 years of teaching experience, most of whom are preschool teachers with more than 8 years of teaching experience.

Table 1. Demographic Profile of Respondents

Valid	Options	Frequency	Percent
Teacher Age	20-30years old	169	62.1
	31-40years old	88	32.4
	41-50years old	15	5.5
Teacher Gender	female	265	97.4
	male	7	2.60
Teaching Experience	1-2 years	65	23.9
	3 years	24	8.8
	4 years	24	8.8
	5-7 years	75	27.6
	8 years and above	84	30.9

4.2 Descriptive Analysis, Reliability, and Validity

Table 2 shows that there are 272 valid questionnaires; the minimum value is 1, and the maximum value is 5, all within the range of 1-5, indicating that these variables have no filing errors; the average value is between 3.6 and 4.09, indicating that the data is not too concentrated. Values greater than the 3.4 indicate that the means for variables related to teachers' intention and usage behavior show moderately positive views (Issam Khalil Abu-Baker et al., 2019).

The skewness value of each item is between -1.427~0.379, and the kurtosis value is between -0.937~1.764, which is in line with Tabachnick and Fidell (2019) suggested that univariate skewness values should be < |2| and univariate kurtosis values should be < |4| to provide a normal distribution, indicating that there is no serious deviation in the research data.

Table 2. Descriptive statistics and measurement model: Reliability and validity

Construct	Items	Mean	SD	CA	Convergent Validity			Skewness	Kurtosis
					Std.	CR	AVE		
PE	PE1	3.82	1.15	0.858	0.806	0.890	0.617	-0.787	-0.198
	PE2	3.81	1.229	0.860	0.795			-1.007	0.026
	PE3	3.93	1.191	0.875	0.741			-0.913	-0.224
	PE4	3.83	1.077	0.869	0.775			-0.677	-0.39
	PE5	3.6	1.161	0.858	0.810			-0.813	-0.058
EE	EE1	3.64	1.144	0.774	0.640	0.801	0.503	-0.397	-0.917
	EE2	3.7	1.132	0.741	0.711			-0.693	-0.308
	EE3	3.68	1.126	0.746	0.694			-0.603	-0.587
	EE4	3.77	1.162	0.758	0.783			-0.812	-0.424
SI	SI1	4.04	1.081	0.897	0.786	0.914	0.680	-1.176	0.8
	SI2	3.97	1.078	0.902	0.761			-1.427	1.764
	SI3	4.09	1.005	0.893	0.824			-1.21	1.251
	SI4	3.98	1.04	0.892	0.811			-1.134	0.813
	SI5	4.02	1.013	0.870	0.931			-1.333	1.61
FC	FC1	3.94	1.127	0.937	0.868	0.945	0.810	-0.89	-0.337
	FC2	3.99	1.103	0.917	0.929			-1.15	0.461
	FC3	3.89	1.115	0.935	0.873			-0.956	0.022
	FC4	3.95	1.099	0.915	0.929			-0.956	-0.114
HM	HM1	3.61	1.194	0.914	0.838	0.927	0.761	-0.554	-0.727
	HM2	3.68	1.219	0.895	0.899			-0.704	-0.589
	HM3	3.83	1.2	0.911	0.854			-0.677	-0.766
	HM4	3.78	1.156	0.897	0.897			-0.564	-0.937
LV	LV1	3.72	1.205	0.842	0.885	0.890	0.670	-0.691	-0.581
	LV2	3.76	1.204	0.873	0.765			-0.701	-0.573
	LV3	3.66	1.244	0.866	0.791			-0.696	-0.466
	LV4	3.71	1.14	0.850	0.829			-0.652	-0.426
HT	HT1	3.8	1.158	0.903	0.793	0.914	0.728	-0.899	0.018
	HT2	3.88	1.115	0.879	0.881			-1.27	0.971
	HT3	3.9	1.101	0.894	0.830			-1.056	0.558
	HT4	3.97	1.111	0.878	0.904			-1.072	0.331
BI	BI1	3.78	1.026	0.776	0.772	0.833	0.625	-0.819	0.066
	BI2	3.86	1.09	0.714	0.842			-1.105	0.585
	BI3	3.88	1.076	0.801	0.755			-0.895	0.126
UB	UB1	4.01	1.059	0.771	0.888	0.874	0.699	-0.991	0.136
	UB2	3.91	1.074	0.860	0.775			-0.805	-0.324
	UB3	3.88	1.006	0.818	0.842			-0.857	0.152

The factor loadings (FL) were higher than 0.30 and all variables demonstrated Cronbach's Alpha (CA) values ranging from 0.714 to 0.937, surpassing the acceptable threshold of 0.7 (Hair et al., 2009). These results indicate strong internal reliability for the multi-item scales used to measure the technology acceptance constructs. Composite reliability (CR) values range from 0 to 1, with a minimum threshold of 0.7, indicating good reliability and convergent validity (Hair et al., 2009). As can be seen from Table 2 that all constructs demonstrated CR above 0.7. In addition, the AVE of variables ranged from 0.529 to 0.657. AVE exceeding 0.5 signs the construct explains over half the variance in its indicators, demonstrating convergent validity (Hair Jr et al., 2014). Together, the factor loadings, CR, and AVE provide compelling evidence of convergent validity at both the item and construct levels.

Table 3. Correlation matrix and square root of the AVE

	PE	EE	SI	FC	HM	LV	HT	BI	UB
PE	**0.786**								
EE	0.504	**0.709**							
SI	0.456	0.489	**0.825**						
FC	0.431	0.379	0.452	**0.900**					
HM	0.417	0.502	0.494	0.489	**0.872**				
LV	0.359	0.329	0.427	0.431	0.355	**0.819**			
HT	0.391	0.47	0.558	0.496	0.516	0.325	**0.853**		
BI	0.526	0.568	0.575	0.547	0.571	0.385	0.605	**0.791**	
UB	0.533	0.492	0.588	0.533	0.452	0.353	0.54	0.508	**0.836**

Note. Diagonal values show the square of AVE.

In addition, the diagonal of the discriminant validity is the root mean square of the AVE value of each construct, and the lower triangle area of the other diagonal is the Pearson correlation. As shown in the results of Table 3, the mean square root of all AVEs is greater than the standardized correlation coefficients of this construct with other constructs.

4.3 Model Fit Analysis

Model fit analysis was examined using seven fit indices, as recommended by Marsh and Hocevar (1985), Fabrigar et al. (1999), Hu and Bentler (1999), Mulaik et al. (1989). These indices comprise the ratio of $\chi 2$ to the degree of freedom ($\chi 2$/df), the Root Mean Square Error Approximation (RMSEA), Incremental Fit Index (IFI), Bentler and Bonett's Fit Index (NFI or TLI), Comparative Fit Index (CFI), Parsimony Goodness of Fit Index (PGFI), Parsimony Normed Fixed Index (PNFI). As presented in Table 4, all fit indices had estimated values within the recommended range, indicating a good fit from the measurement model.

Table 4. Fit Model Indices Analysis

Fit Indices	Recommended Value	Estimated Value	
		Measurement Model	Structural Model
$\chi 2$ /df	<5	2.061	2.106
RMSEA	<0.80	0.063	0.064
IFI	>0.90	0.920	0.916
TLI	>0.90	0.909	0.905
CFI	>0.90	0.919	0.915
PGFI	>0.5	0.689	0.692
PNFI	>0.5	0.757	0.760

4.4 Structural Model Analysis

The results of the structural model analysis indicate that 9 of 10 hypotheses were supported, as presented in Table 5 and Figure 1. The results were as follows: PE ($\beta = 0.157$, $t = 2.327$, $p < 0.05$), EE ($\beta = 0.183$, $t = 2.400$, $p < 0.05$) , SI ($\beta = 0.155$, $t = 2.184$, $p < 0.05$) , FC ($\beta = 0.155$, $t = 2.346$, $p < 0.05$), HM ($\beta = 0.153$, $t = 2.225$, $p < 0.05$) and HT ($\beta = 208$, $t = 2.911$, $p < 0.05$) had a significant positive influence on BI. FC ($\beta = 0.272$, $t = 3.948$, $p < 0.001$), HT ($\beta = 0273$, $t = 3.610$, $p < 0.001$), and BI ($\beta = 0.229$, $t = 2.771$, $p < 0.001$) had a significant positive influence on UB. In addition, LV ($\beta = 0.019$, $t = 0.308$, $p > 0.05$), had not significant positive influence on BI. Thus, all hypotheses were supported and shown in Table 5 and Figure 1.

Table 5. Path Analysis

Suppose	Path from/to			Standardized Estimate (B)	SE	C.R.	P	Hypothesis
H1	BI	<---	PE	0.157	0.057	2.327	0.020	supported
H2	BI	<---	EE	0.183	0.082	2.400	0.016	supported
H3	BI	<---	SI	0.155	0.066	2.184	0.029	supported
H4	BI	<---	FC	0.155	0.053	2.346	0.019	supported
H5	UB	<---	FC	0.272	0.067	3.948	***	supported
H6	BI	<---	HM	0.153	0.054	2.225	0.026	supported
H7	BI	<---	LV	0.019	0.045	0.308	0.758	rejected
H8	BI	<---	HT	0.208	0.061	2.911	0.004	supported
H9	UB	<---	HT	0.273	0.078	3.610	***	supported
H10	UB	<---	BI	0.229	0.100	2.771	0.006	supported

→: represents path; ***, ** and * express P<0.001, P<0.01 and P<0.05

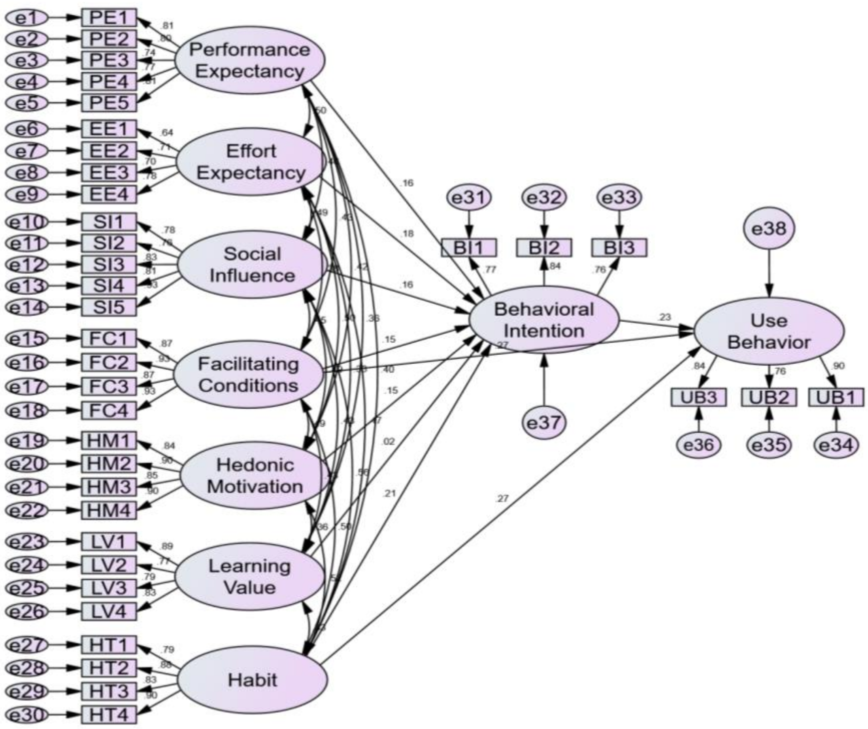

Fig. 2 Structural model results

5. Discussion and Implications

In the context of science education teaching practice, this study focuses on research issues and carries out related research. Firstly, based on combining the relevant literature and theoretical research, a UTAUT2-based model of mobile learning adoption and acceptance intention of in-service preschool teachers in science teaching practice is constructed, and relevant research hypotheses are put forward. Secondly, the in-service preschool teachers in Wuyishan City, China, were selected as the research samples, and the survey data were analyzed by using SPSS 22.0 and AMOS 22.0. Nine core influencing factors of performance expectation, effort expectation, social influence, facilitation condition, hedonic motivation, learning value, habit, behavioral intention, and usage behavior were extracted, and then, the research conducted verification research on the constructed model. This following will analyze these 10 hypothesis relationships and discuss the results of hypothesis testing.

Performance expectancy is a significant predictor of behavioral intention to use m-learning. From Table 5.11, it can be observed that the path coefficient of PE on BI is significantly positive ($\beta = 0.157$, $p < 0.05$), providing evidence to support the acceptance of hypothesis H1. Users develop a positive attitude towards computer use when they perceive technology to be useful (Davis, 1989). This may be due to the in-service teachers feeling the effects of mobile learning and the expected value created by successful teaching cases. Many studies are consistent with the findings of this study. Studies by researchers, such as Nikolopoulou et al. (2021) in Greece, Zacharis and Nikolopoulou (2022) in Greece, and Dajani and Abu Hegleh (2019) in Jordan, have shown consistent results.

The path coefficient of EE on BI is significantly positive ($\beta=0.183$, $p<0.05$), providing evidence to support the acceptance of hypothesis H2. When teachers believe they can operate mobile learning, they will tend to use it in teaching activities. This may be because in-service teachers feel that mobile learning is easy to use, and the friendly and intuitive platform makes it easy for preschool teachers to accept and adopt it. The support from training and the integration of practice has reduced the incompatibility of in-service preschool teachers in adopting and using mobile learning, especially because the acquisition of resources and the teaching effect outweigh the effort. This finding is consistent with previous research (Alghazi, Kamsin, et al., 2021a; Dahri et al., 2023), which has shown that perceived ease of use is a crucial factor in mobile learning acceptance.

Hypothesis H3 proposes that social influence (SI) plays a significant role in shaping the behavioral intention (BI) of kindergarten teachers to accept and use mobile learning in science education teaching practices. In a sense, preschool teachers' knowledge of social influencing factors will continually grow thanks to the acknowledgment and encouragement of educational leaders, school administrators, and fellow educators. These findings support prior studies, Arsim Fidani (2012) reported that social influence significantly affects behavioral intention to accept LMS (Learning management system). Xu et al. (2021) also found similar results. Peer recognition and recommendation can promote the effective occurrence of teachers' teaching reflection through their social influence on teachers.

The path coefficient of FC on BI is significantly positive ($\beta=0.155$, $p<0.05$), providing evidence to support the acceptance of hypothesis H4. Hypothesis H5 suggests that facilitating conditions play a significant role in influencing the actual use behavior (UB) of kindergarten teachers in using mobile learning in science education teaching practices. In mobile learning settings, technical support teams can be considered as a facilitating condition that helps users feel comfortable when participating, thus increasing their behavioral intention (Su & Chao, 2022). According to Alghazi, Kamsin, Almaiah and Shuib (2021), it was demonstrated that the impact of device functionality, device compatibility, network speed, and pricing value on the intention to use m-learning was highly effective. These results support the previous research. The relationship between FC and UB has been demonstrated in studies by Khan et al. (2021) in Pakistan, studies by Puriwat and Tripopsakul (2021) in Thailand, and studies by Arif et al. (2022) in Indonesia.

Hedonic motivation revealed a significant prediction of both users' intentions of mobile technologies. It has been shown to play an important role in determining technology acceptance and use, and it has also been found to be an important determinant of technology acceptance and use (Venkatesh et al., 2012). It can be observed that the path coefficient of HM on BI is significantly positive ($\beta=0.153$, $p<0.05$), providing evidence to support the acceptance of hypothesis H6. This is consistent with the findings of Hu et al. (2020) when exploring the factors influencing the adoption of emerging mobile technologies in academia.

According to Venkatesh et al. (2012) and Nikolopoulou et al. (2021), habit has been recognized as a determinant of using technology together with intention. Hypothesis H8 suggests that the habit of using mobile learning influences kindergarten teachers' behavioral intention to accept and use it in their science education teaching practices. Hypothesis H9 suggests that habit influences the use behavior of kindergarten teachers in using mobile learning in their science education teaching practices. The study by Hu et al. (2020), which looked at the factors affecting the adoption of new mobile technologies in academia, supports this research by concluding that habit has a substantial impact on willingness. The research of Makanyeza and Mutambayashata (2018) on consumer acceptance and use of plastic money confirms this. Similarly, as mentioned by Khan et al. (2021), in predicting customers' behavioral intentions (BI) from Pakistan and Turkey's use of online banking, habit is one of the important predictors of BI and UB, indicating that once a customer is used to using any system, it will accept it. The results also showed that HT directly affects UB in the absence of BI mediation.

Hypothesis H10 suggests that the behavioral intention to use mobile learning influences the actual use behavior of kindergarten teachers in their science education teaching practices. The significant positive path coefficient of 0.229 indicates that behavioral intention plays a crucial role in shaping teachers' use behavior of mobile learning. BI had a significant effect on the USE. Many studies have confirmed that BI affects the actual usage positively (Dajani & Abu Hegleh, 2019; Khan et al., 2021; Novitaningtyas et al., 2020; Puriwat & Tripopsakul, 2021; Xu et al., 2021; Zacharis & Nikolopoulou, 2022).

In contrast to the above conclusions, it can be observed that the path coefficient of LV on BI is positive ($\beta=0.019$, $p>0.05$), but it is not statistically significant, supporting the acceptance of hypothesis H7. Regarding LV, some studies have reported that it is a predictor of college students' willingness to accept technology, such as the research of Ain et al. (2016) and the research of Zacharis and Nikolopoulou (2022). Similarly, this study is different from the results of Ain et al. (2016) research on the effect of learning value on the use of learning management systems. However, the non-significant relationship between LV and BI indicates that perceived learning value alone may not significantly impact teachers' intentions in this context. The analysis of H7 highlights the complexity of factors influencing technology acceptance and underscores the need to consider other variables and influences that may play more significant roles. Future research should explore additional factors and contextual variations to gain a more comprehensive understanding of technology adoption among kindergarten teachers.

With the rapid development of mobile technology, mobile learning, as a new model, promotes the transformation of traditional teaching from an old paradigm to a new paradigm. "Mobile learning + early childhood science education" provides a new paradigm, showing a positive integration trend. In this study, PE, EE, SI, FC, HM, and HT had significant positive effects on BI, and FC, HT had significant positive effects on UB, suggesting that these factors play a crucial role in shaping teachers' intention to accept and use mobile learning. This analysis contributes to theory development, it provides empirical evidence specific to kindergarten teachers' perceptions and intentions related to mobile learning adoption in science education. Customizing the model to teachers' needs and quantitatively validating hypothesized relationships expands and enriches UTAUT2 as a theoretical lens for studying technology acceptance within diverse educational environments.

In addition, by considering the factors identified in the model, policymakers can design strategies and initiatives that promote technology acceptance, address adoption barriers, and create an enabling environment for technology integration. Its impact ranges from enhancing research methods to informing policy development, teacher training, user support, and market analysis. First, a primary finding was teachers' positive performance expectancy perceptions, indicating they recognized the benefits of mobile learning for enhancing instructional practices and student engagement. However, effort expectancy had an even stronger influence, underlining the need to minimize perceived complexity through training and mobile device design. Developing teachers' technical competencies is imperative, as self-efficacy strongly predicts technology adoption (Nikolopoulou & Gialamas, 2015). Government policymakers can leverage technology acceptance models to inform policy formulation related to technology adoption in different sectors (Nisson & Earl, 2021). Training programs should incorporate hands-on exploration of mobile learning tools and evidence-based techniques to apply them in science education contexts. Second, adequate technological provisions and technical assistance should accompany any initiatives promoting mobile technology integration. User-friendly, reliable design of mobile apps can further encourage effortless utilization. Teachers should choose properly designed educational apps with educational goals for their classroom or online instruction (Nikolopoulou et al., 2021). Third, building professional communities to share mobile learning insights and providing organizational recognition for innovative practices can help normalize adoption. Successful teaching experiences provide teachers with positive feedback on their intention to accept and use mobile, while participatory, experiential teaching practices can appropriately reduce discomfort during technology use. The cooperation, sharing, and communication among peers can be beneficial to enhance the confidence and motivation of preschool teachers to accept and use mobile learning. Furthermore, leveraging hedonic motivations and developing habitual use are important for sustained adoption. Gamification, multimedia, and personalized content can stimulate intrinsic pleasures that positively reinforce usage. In addition, making periodic mobile learning adoption a school-wide goal through training schedules and learning communities can instill automatic engagement over time.

6. Implications on Training Teachers

Continuing professional development is critical to continued growth and success in a teacher's career. On-the-job training enhances an individual's quality of life by providing professional, personal and social development (Ayvaz-Tuncel & Çobanoğlu, 2018). Use higher education teaching venues or training bases to carry out special training to ensure that teachers use mobile terminal skills to improve the self-efficacy and career development opportunities of in-service kindergarten teachers. Through training, teachers' professional skills, attitudes and values can be improved, ultimately improving teachers' overall performance and professional development.

Comprehensive teacher training is crucial for the successful integration of mobile learning in early childhood scientific education. Training programmes should prioritise the following areas:

1. Improving Technical Competencies: Prioritise practical experimentation and the cultivation of technical abilities to enhance teachers' confidence and effectiveness in utilising mobile devices. Emphasising the importance of continuous professional development is crucial.
2. Creating intuitive and accessible tools for users: Provide guidance to educators in choosing suitable educational applications and prioritise user-friendliness. Offer comprehensive technical assistance to assist educators in overcoming obstacles related to integration.
3. Establish professional communities to facilitate the exchange of experiences and insights among teachers on mobile learning. Identify and endorse inventive strategies to encourage the acceptance and implementation of new ideas. Promote peer collaboration to bolster confidence and motivation.
4. Utilise hedonic motivation and habit formation by integrating gamification and multimedia elements into training programmes to enhance learner engagement. Encourage regular utilisation of mobile learning tools by implementing organised timetables and fostering learning communities.

5. Policy and Strategic Initiatives: Policymakers ought to formulate favourable policies, tackle obstacles to adoption, and establish conducive conditions for the integration of technology. This entails supplying essential resources and cultivating a culture that promotes creativity.

Training programmes can equip instructors with the necessary skills to utilise mobile learning successfully, hence improving instructional practices and increasing student engagement in early childhood scientific education.

7. Limitations and Future Studies

The research on teachers' acceptance of mobile learning is still in a stage of continuous exploration and development. This paper only conducts preliminary exploratory research on the acceptance level of mobile learning in the teaching practice of science education by in-service preschool teachers. Although the standardization of the research has been maintained throughout the research process, there are few literatures on in-service preschool teachers' acceptance of mobile learning, and they are limited by research time and conditions, personal ability, and energy. Therefore, there will inevitably be certain limitations and deficiencies in the research process. Firstly, a primary limitation of the current study is its restricted geographic scope, with the sample drawn only from kindergarten teachers in Wuyishan City. Secondly, with the continuous development of early childhood education and the growth and changes in the preschool teacher community, it is not ruled out that the factors affecting the acceptance of mobile learning by preschool teachers may also involve other undiscovered influencing factors. Meanwhile, the research method adopts quantitative research, which is relatively simple.

There are still a lot of problems that need to be further studied in the future. First, expanding scope and sample representativeness. Validating the model across broader samples is necessary for generalizable insights that guide countrywide adoption. This expansive scope can help identify potential geographic variations in the relationships between acceptance factors and behavioral intentions. In the study, UTAUT2 provides a parsimonious baseline model of established technology acceptance determinants. To enrich theoretical understanding, expanding the model with additional constructs relevant to educational contexts can be productive. Exploring additional technology-specific and education-focused factors beyond UTAUT2 can expose new relationships to expand acceptance models. Continuously evolving contextualized models are central to advancing technology acceptance research and bridging theory with practice. Meanwhile, longitudinal tracking can illuminate attitude changes over time. In addition, a mixed-methods approach combining surveys, observations, and interviews can overcome the limitations of single techniques.

8. Conclusion

Mobile learning is an innovation of traditional teaching reform. Since the day of mobile learning, it has been integrated with the blood of technology and innovation. In the information age, mobile learning has realized the important transformation of "situational" and "autonomous learning". However, according to the level of economic and educational development in different regions, people's acceptance and adoption of mobile learning are relatively different, but teachers' attitudes towards mobile learning do play a crucial role. Altogether, the findings suggest that factors such as performance expectancy, effort expectancy, social influence, facilitation conditions, hedonic motivation, and habit play key roles in promoting teachers' behavioral intention to accept and use mobile learning. The two factors of facilitation conditions and habit have a direct relationship with the behavior of preschool teachers accepting and using mobile learning. The findings provide theoretical advancements, practical implications, and future research directions that can inform policies and initiatives aimed at promoting the integration of mobile learning in early science education. At the same time, the study hopes that science educators, instructional designers, and mobile developers will expand on this research and continue to explore if, when, and how mobile technology can be used in science classrooms. It would be a significant step in the right direction to respond to the current request for a more focused and tangible integration of technology into the science curriculum.

9. Co-author contribution

The authors affirmed that there is no conflict of interest in this article. Author 1 conducted the fieldwork, completed the literature review, and composed the entire article. Author 2 and Author 3 provided supervision to Author 1, thoroughly proofread the article, and offered suggestions for improvement.

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