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Exploring acceptance toward tablet-based learning among K-12 students in Southeast China: Age and gender differences

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Abstract
Tablet-based learning is increasingly popular in K–12 education worldwide. Acceptance of this learning method is crucial for its successful implementation in schools. Pertinent research indicated that males and females used technology differently, and younger and older users had unique technology acceptance. Understanding these gender and age differences can lead to more effective and positive learning experiences for K–12 students. While some studies have examined mobile learning acceptance in other countries, the results may differ in the context of China. This study used exploratory factor analysis, confirmatory factor analysis, two-way between-subjects ANOVA, multiple regression, and two-way between-subjects MANOVA to analyze data collected among 658 K–12 students with tablet-based learning experiences in Zhejiang province, southeastern China. Results indicated there were significant gender and age differences in the acceptance of tablet-based learning among K–12 students. In addition, performance-effort expectations, social influence, and technology self-efficacy for problem-solving were determined to be the main determinants of K–12 students' acceptance of tablet-based learning. Age and gender differences existed in performance-effort expectations, and only age differences existed in social influence. These findings offer theoretical and practical insights for future research. Practitioners can redesign tablet-based learning based on these main determining factors and differences. In addition, this study provides researchers with a perspective to add technological self-efficacy to UTAUT in a new context.

Keywords Tablet-based learning · Technology acceptance model · Performance-effort expectancy · Social influence · Age difference · Gender difference

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Introduction

As the world becomes increasingly digital, students need to be prepared for the challenges of the future learning (Kalolo, 2019). Technology acceptance (TA) could be a crucial indicator for improving and diffusing learning in technology-enhanced educational contexts (Granić & Marangunić, 2019). Tablet-Based Learning (TBL) has gained popularity in the field of education worldwide over the past two decades because of its many benefits, particularly during the COVID-19 pandemic (Abdel-Hameed et al., 2021; Alabdulaziz, 2021; Goksu, 2021; Matzavela & Alepis, 2021; Yuan et al., 2021). Despite advanced communication technology, TBL is still in the implementation stage, especially in developing countries (Almaiah et al., 2022). Studies conducted in some countries and areas found relatively low acceptance of TBL in their regions, suggesting that learning with tablets continues to encounter challenges regarding TA (Almaiah et al., 2016, 2020; Rafique et al., 2020; Sinaga et al., 2022; Villani et al., 2018), even in some developing countries and regions where they are not yet widely used, such as China. TA may vary due to social and cultural barriers (Al-Adwan et al., 2018).

In China, mobile devices initially entered higher education with modest attempts at TBL in available areas (Wang et al., 2005; Wang, Wijaya, Habibi, & LiWang et al., 2022a, b; Wang et al., 2009; Yuan et al., 2021). TBL has gradually been found to have some benefits in Chinese K-12 education, but there are also some drawbacks, especially during the pandemic period (Zuo et al., 2021). However, there is still relatively little research to reveal acceptance of TBL in Chinese K-12 schools. In addition, there might be a certain difference in acceptance of mobile technology in different regions of China due to differences in regional culture and economic development (Song et al., 2012). Hence, exploring acceptance toward TBL among K-12 students in Southeast China could contribute new perspectives on TA study.

Besides that, the acceptance of TBL could be influenced by many factors, and figuring out these factors is beneficial to the high quality of TBL (Alghazi et al., 2020; Almaiah et al., 2022; Alshurideh et al., 2023; Chavoshi & Hamidi, 2019). Understanding these factors that influence students' acceptance of TBL is crucial for its effective use and can be considered a prerequisite for integrating TBL in K-12 schools (Nikolopoulou, 2018; Pratama, 2021). The same goes for them in Chinese K-12 schools. On the other hand, age and gender are important moderating variables that affect the intention to use new technologies, and the differences between them should not be ignored (Venkatesh et al., 2003; Wang et al., 2022a, b; Yun & Cho, 2022).Age and gender differences have been studied on acceptance of TBL or computer software in K-12 education in other regions and countries (Abidin et al., 2018; Arroyo et al., 2013; Cacciamani et al., 2018; Christensen et al., 2005; Dündar & Akçayır, 2014; Nikolopoulou, 2018; Pratama, 2021; Vale & Leder, 2004; Villani et al., 2018). However, the findings regarding gender and age differences in users' TA vary across different (national and professional) cultures (Nistor et al., 2013). Chinese K-12 students may exhibit different results in terms of TBL's acceptance in China's socio-cultural background, including gender and age. Recognizing age and gender differences on acceptance of TBL could provide insights for technology developers, policy makers, and teaching practitioners to make tailored adjustments in

K-12 education (Nikolopoulou, 2018; Pratama, 2021; Wang et al., 2009). In addition, revealing these differences could provide a comparative perspective for the application of TBL in other cultural backgrounds.

The Unified Theory of Acceptance and Use of Technology (UTAUT) is among the most influential theoretical models that explain user acceptance of innovative technologies in education, which could be extended (Alghazi et al., 2020; Moran et al., 2010; Tian & Yang, 2023; Venkatesh et al., 2003). This study extends the validity of the UTAUT theory in Chinese K-12 education by incorporating Technological Self-Efficacy (TSE) as a dependent variable to the UTAUT model. The study aims to reveal key factors influencing their TBL acceptance, also age and gender differences in these different domains. Some theoretical and practical implications related to acceptance of TBL in K-12 schools could be offered for other regions of China, the Asia-Pacific region, and other developing countries.

Literature review

Mobile learning refers to the learning process that is facilitated by mobile devices such as smartphones, personal digital assistants (PDA) and tablets (Ahmad Faudzi et al., 2023; Bringula & Atienza, 2023; Mohtar et al., 2023). Tablets have emerged as one of the primary tools used for mobile learning worldwide due to their low cost, lightweight nature, portability, interactive features, and pedagogical advantages (Ahmad Faudzi et al., 2023; Almaiah et al., 2020; Cacciamani et al., 2018; Ifenthaler & Schweinbenz, 2016; Sinaga et al., 2022; Wang et al., 2022a, b).

Since 2005, mobile learning has become popular in China (Liu et al., 2010). In Chinese K–12 education, although TBL has brought some benefits, such as creating harmonious teacher-student relationships and smooth learning processes, allowing students to acquire more knowledge, and improving learning efficiency, there are also some challenges, such as eye fatigue caused by long-term reading, lack of social interaction, unstable networks (lagging, delayed, offline), insufficient learning device functionality, a lack of timely feedback, guidance, and supervision, and unfamiliarity with platforms or software, etc. (Zuo et al., 2021). In the face of these uncertain impacts, it is necessary to investigate TBL acceptance of Chinese K-12 students. However, research on TBL acceptance in China mostly focuses on higher education, K-12 teachers, and older adults (Bao et al., 2013; Hao et al., 2017; Liu & Li, 2011; Liu et al., 2010; Wang et al., 2022b; Xu & Zhu, 2020; Zhao et al., 2021).

Gradually, some studies have also begun to pay attention to the study of students' acceptance of TBL in Chinese K-12 education. One technology acceptance patterns of Chinese elementary school students towards TBL was studied by Sun and Jiang (2015), but detailed information on acceptance has not been revealed. Liu et al. (2018) suggested perceived responsiveness and self-efficacy were both predictive factors for perceived ease of use and perceived usefulness, and the improvement of self-efficacy had significant benefits for the use of mobile devices in secondary school. Previous study also revealed that the behavioral intention of rural middle school students was significantly influenced by perceived usefulness of mobile devices, convenience conditions, and usage attitudes (Guo et al., 2020). Zheng and Li (2020) found fac-

tors such as self-efficacy, technical anxiety, and family support had an impact on the secondary students' acceptance of TBL. Zhang (2021) investigated the views of Chinese middle school students on TBL and examined their acceptance of TBL in the teaching environment. Overall, the above research to some extent reveals the acceptance of TBL among Chinese K12 students, but most studies focus on a small area with limited explanatory power. TBL could be influenced by many factors (Kumar & Chand, 2019). Furthermore, the age and gender differences in TBL acceptance among Chinese K-12 students have hardly been revealed. Anyway, there are still gaps in research in this area.

But age and gender differences in TBL acceptance among K-12 students have been studied in other region and countries. Previous studies indicated that boys showed a more positive attitude towards the use of mathematical technology than girls (Abidin et al., 2018; Vale & Leder, 2004). However, another study showed that female students were more willing to accept technology and benefit a lot from it, especially when their learning partners were present (Arroyo et al., 2013). In addition, a survey of 10,000 students in grades 3 to 12 in public schools showed that girls in grades 4 and 5 liked computers better than boys, although there was almost no difference between boys and girls in their attitudes towards computers at the beginning of grade 1. From about grade 6, girls' self-reported views on computers began to become less positive than boys' and were significantly lower than boys' in grade 8, and boys' and girls' attitudes towards computers would become similar again by the end of middle school (Christensen et al., 2005).

Furthermore, research results of Villani et al. (2018) showed that there were significant differences in the acceptance of TBL in terms of gender, grade level, and frequency of use. Middle school students had higher acceptance and recognition of tablet computers, while young and old students had moderate acceptance and recognition of tablet computers. The higher the frequency of use, the stronger the students' cognition. Similarly, another study also showed that the higher the grade (or age group), the higher the frequency of surfing the Internet through mobile devices, and the longer the years of using mobile devices, the more positive the students' views (Nikolopoulou, 2018). Pratama (2021) claimed that there were gender and age differences in the influence of perceived liquidity value and perceived usefulness on the acceptance of mobile learning, especially among women and senior high school students; in addition, there were gender and age differences in the influence of facilitating conditions on the acceptance of mobile learning, especially for women and middle school students. On the contrary, a study showed that there were no differences in the influence of gender on TBL's acceptance (Dündar & Akçayır, 2014). In addition, the research showed that there was neither age difference nor gender difference in acceptance of TBL (Cacciamani et al., 2018).

Although there are many studies on gender and age differences worldwide in TBL acceptance among K-12 students. However, socio-cultural differences may lead to differences in technology acceptance in terms of age and gender (Nistor et al., 2013). Therefore, revealing the differences in age and gender among Chinese K-12 students regarding TBL may contribute new perspectives. In addition, there is a mature theoretical lens called the UTAUT framework put forward by Venkatesh et al. (2003),

which integrates the above factors, including the moderate effect of age and gender, can be used to study the social factors influencing TA in a particular context.

Theoretical framework

UTAUT was chosen as theoretical framework because of its widespread use in measuring acceptance toward innovative technologies and its strength in identifying various factors that influence adoption (Venkatesh et al., 2003; Alghazi et al., 2020; Lehmann et al., 2022). As an extension of the Technology Acceptance Model (TAM), many studies have demonstrated the effectiveness of the UTAUT in explaining technology adoption (Chen et al., 2023; Shin, 2009). TAM tends to focus on external variables and overlook the social background and other detailed indicators of technology adoption, such as cost, etc., (Chao, 2019; Shin, 2009). The UTAUT model clearly explains the detailed predictive factors of user behavior in organizational environments (Chen et al., 2023). In addition, TAM may have limited ability to explain technology adoption, while UTAUT models can explain 70% of user intention variance and 50% of technology usage variance through multiple variables (Chao, 2019; Venkatesh et al., 2012). As a reasonable comprehensive enhancement of TAM, UTAUT can serve as a theoretical framework for acceptance research of technology (Lehmann at al., 2022).

Within the UTAUT model, Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), and Facilitating Conditions (FC) are direct predictors of behavioral intention to use technology (Alghazi et al., 2020; Cacciamani et al., 2018; Chao, 2019; Lehmann et al., 2022; Long et al., 2019; Nikolopoulou et al., 2020; Tian & Yang, 2023; Venkatesh et al., 2003; Villani et al., 2018; Wang et al., 2022a, b). According to Venkatesh et al. (2003)' view, PE refers to users' perception of how much technology can improve their job performance. In this study, it is described as the extent to which students believe that using tablets can enhance learning outcomes. EE is the degree to which users believe utilizing technology can reduce the required effort. This study is characterized by the extent to which students believe that tablets can make learning less effortful. SI refers to the extent to which an individual perceives that someone important to them thinks they should or should not adopt new technology. This study pertains to the degree to which students rely on the opinions of others who think they should use tablets for learning. FC refers to the extent to which users believe that existing organizational and technological structures support technology use. This study characterizes the extent to which students feel supported in their use of tablets for learning.

However, in some cases, the use of UTAUT model has limitations and needs to be modified and extended (Ain et al., 2016; Chao, 2019; Nikolopoulou et al., 2020; Tian & Yang, 2023; Venkatesh et al., 2003). Self-efficacy is defined as the generation of ability by organizing cognitive, social, and behavioral sub-skills into a comprehensive action plan to serve various purposes (Bandura, 1982). TSE refers to the ability of individuals to use technology to accomplish complex tasks (Compeau & Higgins, 1995). It is important to determine whether students are likely to use technology to support their learning (Al-Adwan et al., 2023; Huffman at al., 2013; Wang et al.,

2023). Previous studies have demonstrated that TSE can influence TA, leading to its inclusion as an additional proposed determinant in this study (Al-Adwan et al., 2023; Huffman at al., 2013; Moran et al., 2010; Wang et al., 2023). In this study, it refers to the ability of students to use tablets to complete learning tasks.

Methodology

Participants

In China, Zhejiang Province has undertaken precision teaching experiments in K-12 education, with TBL serving as a prime example. This technological reform aims to explore whether mobile device can be more effectively employed in K-12 context to enhance teaching quality and facilitate student's personal learning. The researchers contacted the local education management department and randomly selected approximately the same number of primary, middle, and high school participants through stratified sampling. Accordingly, a total of 667 K-12 students from the rapidly developing southeastern Chinese province of Zhejiang participated in this study. They were deliberately chosen due to their willingness to cooperate with the survey and their schools' participation in a TBL pilot program sponsored by the government since 2015, which gave them a minimum of six months of experience with TBL. As a result, they possess relatively rich experiences with TBL learning and can provide insightful experiential information. In total, 658 valid samples were collected, with male and female students accounting for 50.3% (331 individuals) and 49.7% (327 individuals), respectively. Of these, 33.0% (217 individuals) were elementary school students, comprising 123 boys (56.7%) and 94 girls (43.3%). Junior high school students accounted for 36.0% (237 individuals), with 106 boys (44.7%) and 131 girls (55.3%), while high school students comprised 31.0% (204 individuals) and were evenly split between 102 boys and 102 girls.

Instrument

A survey questionnaire was used to gauge students' acceptance of TBL learning. The questionnaire items were adapted from previous studies (Compeau & Higgins, 1995; Venkatesh et al., 2003). After revision by two industry experts, the final questionnaire was developed, which could be divided into three sections (the main items can be found in the Appendix). The initial section includes six questionnaire items designed to collect demographic information from the participants. These questions address important demographic factors such as age, gender, and place of residence. The purpose of gathering this information is to gain a deeper understanding of the characteristics of the research sample and to analyze potential demographic differences on different variables. The second section comprised 25 items focusing on PE, EE, SI, FC and TSE. The third section encompasses three question items designed to gauge students' acceptance of TBL. These items were designed to evaluate participants' perceptions regarding these variables in the study. The inclusion of these measurement items aimed to offer a comprehensive assessment of all aspects related

to the study's objectives and hypotheses, thereby refining the UTAUT theoretical framework. Both the second and third sections employed a five-point Likert scale, ranging from "1-strongly disagree" to "5-strongly agree". To ensure alignment with the local context, the questionnaire was translated and pilot-tested by nine experienced researchers. After one round of pilot testing, the questionnaire was further refined to enhance its readability and content validity.

Data collection and analysis

The questionnaire was distributed via email, and participants were provided with a brief introduction to the study. Students were informed that participation was voluntary, anonymous, and would not affect their school performance evaluations. Students were also instructed to answer questions based on their personal experiences. Given that some participants were primary school students in grades 1–2, who may have lower literacy skills, they were encouraged to seek clarification from trained teachers who delivered questionnaires if they encountered any unfamiliar terms or concepts.

The data analysis consisted of three main steps. Firstly, TSE was added as a predictor variable for K12 student technology acceptance based on the UTAUT model. Since this study did not use the initial four elements of the UTAUT model directly as dependent variables, exploratory factor analysis (EFA) was conducted to identify the five underlying factor structures of the questionnaire to establish its validity. Confirmatory factor analysis (CFA) then was used to assess the new model's factor loadings, reliability, convergence, and discriminant validity. Additionally, simple descriptive analyses were performed to better understand the participants' characteristics. Multiple linear regression analysis (MLRA) is to model and predict a continuous outcome based on multiple predictors, adjusting for confounders and quantifying relationships. (Draper & Smith, 1998). MLRA was conducted to determine the main determinants of K-12 students' acceptance of TBL. Two-Way ANOVA is to efficiently and comprehensively analyze the effects of two factors (and their interaction) on a dependent variable, providing insights into the main and interaction effects, reducing error, and facilitating complex hypothesis testing in experimental and observational studies (Pandis, 2016). A two-way ANOVA was conducted to investigate whether there were any differences in TBL acceptance levels between genders and grade levels. Two-Way MANOVA is utilized to understand the effects of two factors (and their interaction) on multiple correlated outcomes, controlling for Type I error and providing a comprehensive multivariate analysis (Zhang, 2011). Finally, a two-way MANOVA was used to explore age and gender differences among these main determinants. SPSS version 27 and Amos version 24 software packages were used for all data analyses.

Results

Table 1 presents a breakdown of the basic characteristics of the respondents. It depicts the distribution of 658 individuals in terms of gender and K12 education level. The sample includes almost equal numbers of male (50.3%) and female (49.7%) respon-

Table 1 Respondent characteristics

		Number	Frequency(%)
Gender	Male	331	50.3
	Female	327	49.7
	Total	658	100
K12 level	Primary school	217	33
	Middle school	237	36
	High school	204	31
	Total	658	100

dents. Concerning K12 education level, the majority of the sample attended either middle school (36%) or primary school (33%), while the remaining 31% attended high school. These findings offer valuable insights into the gender and educational background of the surveyed population and can assist in contextualizing the research conducted in this study.

Analysis of measurement

The overall reliability of the test questionnaire was analyzed using SPSS 27 and exploratory factor analysis. KMO and Bartlett's ball shape tests were used as analysis criteria, and the obtained KMO value was 0.78 (>0.5), and the *p*-value was less than 0.001. These results indicated that Bartlett's ball shape test was significant, suggesting that the test questionnaire had good structural validity and was suitable for continuing factor analysis (Gao & Izadpanah, 2023).

Next, EFA was applied, using the principal component analysis method and oblimin as factor extraction and rotation methods, respectively. A new potential factor called technical self-efficacy for problem-solving (TSEPS) was identified. Factors that were not clearly delineated were discarded based on the results of the data provided by the SPSS software. The remaining factors were merged, resulting in a four-factor structure: TSE, performance-effort expectancy (PEE), SI, and TSEPS. The FC factor was removed, which was consistent with a model to construct the acceptance of AI and related technologies by library personnel (Andrews et al., 2021). PE and EE factors were combined to obtain the PEE factor. This treatment was similar to a psychological study by Garland (1984).

Sub-scores of Cronbach's alpha for several factors in TSE, PEE, SI, and TSEPS were all above 0.80, providing strong evidence for reliability (Hair, 2009). After excluding items with factor loadings less than 0.6 using AMOS 24, the remaining items on each scale showed factor loadings greater than 0.6 and reached significance levels (Bagozzi & Yi, 1988). Each latent variable combination reliability CR was greater than 0.6, and each latent variable had an average variance extracted (AVE) value greater than the minimum requirement for mean-variance extraction (Fornell & Larcker, 1981). The test results are shown in Table 2.

Discriminant validity was assessed using AVE and correlation coefficients between variables. Good discriminant validity was established when the square root of AVE (in bold) was greater than the correlation coefficient with other factors in the same column or group (Fornell & Larcker, 1981). Table 3 presents the test results, which indicated good discriminant validity for the scale.

Table 2 The summary of convergent validity assessment

Measurement models		Parameter Significance Estimation				Question Reliability		Combination reliability	Convergent validity
		UnStd.	S.E.	z-value	*P*	Std.	SMC	CR	AVE
TSE	Item1	1				0.789	0.62	0.608	0.925
	Item2	0.985	0.047	20.784	***	0.746	0.56		
	Item3	1.009	0.056	17.971	***	0.663	0.44		
	Item4	1.063	0.049	21.798	***	0.775	0.6		
	Item5	1.019	0.047	21.838	***	0.776	0.6		
	Item6	1.091	0.046	23.972	***	0.833	0.69		
	Item7	1.113	0.048	23.194	***	0.813	0.66		
	Item8	1.065	0.045	23.844	***	0.83	0.69		
PEE	Item1	1				0.833	0.69	0.612	0.903
	Item2	1.03	0.041	25.31	***	0.825	0.68		
	Item3	1.053	0.041	25.925	***	0.839	0.7		
	Item4	0.97	0.04	24.359	***	0.805	0.65		
	Item5	0.897	0.055	16.445	***	0.601	0.36		
	Item6	0.823	0.042	19.415	***	0.684	0.47		
	Item7	0.866	0.044	19.84	***	0.696	0.48		
	Item8	0.846	0.046	18.221	***	0.652	0.43		
SI	Item1	1				0.864	0.75	0.8	0.889
	Item2	1.054	0.049	21.457	***	0.924	0.85		
TSEPS	Item1	1				0.855	0.73	0.718	0.836
	Item2	1.006	0.048	21.007	***	0.84	0.71		

***$p<0.001$; **$p<0.01$; *$p<0.05$

Table 3 Distinct Validity Test

Factor	AVE	TSE	PEE	SE	TSEPS
TSE	0.925	**0.962**			
PEE	0.903	0.525	**0.95**		
SI	0.889	0.604	0.377	**0.943**	
TSEPS	0.836	0.746	0.402	0.492	**0.914**

Once the reliability of the measurement model was established, the maximum likelihood estimation technique was used to evaluate the overall structural model (Ding et al., 1995). The results are summarized in Table 4, which presented the main fit measures commonly used to assess structural models, along with recommended criteria and scores for our measurement models. All scores were within the recommended range (Hayduk, 1987; Bagozzi & Yi, 1988).

Gender and age differences on acceptance of TBL

A 2×3 analysis of variance (ANOVA) was conducted to examine whether there were differences in acceptance of TBL based on gender (male, female) and age (primary, middle, and high school level). The dependent variable was the acceptance of TBL, while the independent variables were gender and age. The results revealed significant main effects for both gender ($F(1, 652)=4.455$, $p<0.05$, $\eta^2=0.007$) and age ($F(2,$

Table 4 Summary of model fitting for measurement models

Fit Index	Recommended criteria	Measurement model
Chi square (x2)	Non-sig	599.926
x2/df	<5.00	4.651
Goodness of Fit Index (GFI)	>0.80	0.903
Adj. Goodness-of-fit index (AGFI)	>0.80	0.872
Comparative fit index (CFI)	>0.90	0.941
Root mean square residual (RMR)	<0.10	0.055
Root mean square error of approximation (RMSEA)	<0.10	0.075
Tucker-Lewis index (TLI)	>0.90	0.930

Table 5 Results of Simple Effects Comparing Age (Grade Level)

Gender	(I) Age (grade level)	(J) Age (grade level)	Mean difference(I-J)	Std.Error	Sig.[a]	95% confidence interval for difference[a]	
						Lower bound	Upper bound
Male	Primary school	Middle school	0.059	0.12	1	-0.229	0.347
		High school	0.688*	0.121	0	0.397	0.979
	Middle school	Primary school	-0.059	0.12	1	-0.347	0.229
		High school	0.629*	0.126	0	0.328	0.931
	High school	Primary school	-0.688*	0.121	0	-0.979	-0.397
		Middle school	-0.629*	0.126	0	-0.931	-0.328
Female	Primary school	Middle school	0.199	0.122	0.315	-0.095	0.493
		High school	0.287	0.13	0.081	-0.024	0.598
	Middle school	Primary school	-0.199	0.122	0.315	-0.493	0.095
		High school	0.088	0.12	1	-0.199	0.375
	High school	Primary school	-0.287	0.13	0.081	-0.598	0.024
		Middle school	-0.088	0.12	1	-0.375	0.199

Note.—Dependent variable: acceptance of TBL.

[a]Adjustment for multiple comparisons: Bonferroni

*means the difference is significant at the 0.05 level

652) = 16.191, $p < 0.001$, $\eta^2 = 0.047$). Females showed significantly higher acceptance levels than males. Primary school students and middle school students displayed significantly higher acceptance levels than high school students.

Additionally, there was a significant interaction between gender and grade level, F (2, 652) = 5.131, $p < 0.01$, $\eta^2 = 0.015$. To better understand the main effects of gender and age on acceptance of TBL, a simple effects analysis was conducted following the significant interaction. The results are presented in Table 5, which indicated that there were significant differences in acceptance of TBL within the male group across primary and high school levels and between middle and high school levels. Both primary and middle school students showed significantly higher levels of acceptance than high school students within the male group.

The results of the simple effect comparing gender are shown in Table 6, which revealed that only at the high school level were there significant gender differences

Table 6 Results of Simple Effects Comparing Gender

Age (Grade level)	(I)gender	(J)gender	Mean difference(I-J)	Std.Error	Sig.[a]	95% confidence interval for difference[a]	
						Lower bound	Upper bound
Primary school	male	female	-0.063	0.124	0.611	-0.307	0.181
	female	male	0.063*	0.124	0.611	-0.181	0.307
Middle school	male	female	0.077	0.118	0.516	-0.156	0.309
	female	male	-0.077*	0.118	0.516	-0.309	0.156
High school	male	female	-0.464*	0.127	0	-0.713	-0.215
	female	male	0.464*	0.127	0	0.215	0.713

Note.—Dependent variable: acceptance of TBL. Based on estimated marginal means

[a]Adjustment for multiple comparisons: Bonferroni

*means the difference is significant at the 0.05 level

Table 7 Multiple Linear Regression Results

Model		Unstandardized Coefficients		Standardized Coefficients	*t*	Sig.
		B	Std.Error	Beta		
1	(Constant)	-0.41	0.155		-2.646	0.008
	TSE	0.054	0.05	0.044	1.085	0.278
	PEE	0.69	0.039	0.569	17.846	0.000*
	SI	0.185	0.035	0.168	5.322	0.000*
	TSEPS	0.116	0.036	0.111	3.18	0.002*

Dependent variable: acceptance towards TBL

in acceptance. Specifically, female high school students tended to have significantly higher levels of acceptance of TBL than their male counterparts.

Gender and age differences on the factors influencing acceptance

A multiple regression analysis was conducted to identify significant factors that could directly predict students' acceptance of TBL. The prediction model fit well ($F(4, 653)=205.697$, $p<0.001$, $R^2=0.558$), accounting for 55.8% of the variance in students' acceptance of TBL. As presented in Table 7, PEE, SI, and TSEPS significantly predicted the acceptance of TBL.

To further investigate the age and gender differences in each significant factor related to the acceptance of TBL, a two-way between-subjects MANOVA was conducted with gender and age as independent variables and PEE, SI, and TSE as dependent variables.

Due to a statistically significant Box's M value of 95.84 ($p<0.001$), indicating that the variance-covariance matrices of the dependent variables across groups of independent variables were heterogeneous, Pillai's trace ($p<0.01$) was used as the necessary measure criteria to evaluate composite multivariate main effects and interaction effect (Mehzabin & Stokes, 2011).

Based on the criterion of Pillai's trace shown in Table 8, no statistically significant complicated multivariate interaction effect emerged across levels of gender * age

Table 8 Results of the composite multivariate tests

Effect		Value	F	Hypothesis df	Error df	Sig.	η^2
Intercept	Pillai's Trace	0.975	8296.720[b]	3	650	0	0.975
	Wilks' Lambda	0.025	8296.720[b]	3	650	0	0.975
	Hotelling's Trace	38.293	8296.720[b]	3	650	0	0.975
	Roy's Largest Root	38.293	8296.720[b]	3	650	0	0.025
Gender	Pillai's Trace	0.025	5.514[b]	3	650	0.001	0.025
	Wilks' Lambda	0.975	5.514[b]	3	650	0.001	0.025
	Hotelling's Trace	0.025	5.514[b]	3	650	0.001	0.025
	Roy's Largest Root	0.025	5.514[b]	3	650	0.001	0.025
Age (Grade level)	Pillai's Trace	0.238	29.372	6	1302	0	0.119
	Wilks' Lambda	0.767	30.738[b]	6	1300	0	0.124
	Hotelling's Trace	0.297	32.107	6	1298	0	0.129
	Roy's Largest Root	0.271	58.780[c]	3	651	0	0.213
Gender * Age	Pillai's Trace	0.017	1.894	6	1302	0.079	0.009
	Wilks' Lambda	0.983	1.898[b]	6	1300	0.078	0.009
	Hotelling's Trace	0.018	1.903	6	1298	0.077	0.009
	Roy's Largest Root	0.017	3.736[c]	3	651	0.011	0.017

Design: intercept + gender + age + gender*age

[b] Exact statistic

[c] The statistic is an upper bound on F that yields a lower bound on the significance level

(F (6, 1302) = 1.894, $p > 0.05$), indicating that the joint effect of independent variables did not significantly account for the total multivariate variance. However, the dependent variable was significantly influenced by both gender and grade level, with Pillai's trace values of 0.025 (F (3, 650) = 5.514, $p < 0.01$, $\eta^2 = 0.025$) and 0.238 (F (6, 1302) = 29.372, $p < 0.01$, $\eta^2 = 0.119$), respectively.

Additionally, separate univariate ANOVA was conducted to determine the significant effects of independent variables (gender and age) on each dependent variable. As three dependent variables were involved, the effects were evaluated against an alpha level of 0.017 (0.05/3 = 0.017). However, because Levene's test of two dependent variables (SI: F (5, 652) = 5.975, $p < 0.001$; TSE: F (5, 652) = 6.803, $p < 0.001$) was statistically significant, indicating that these dependent variables violated the homogeneity assumption of variance, a more stringent alpha level of 0.001 was employed for them.

The between-subject effect test revealed that both gender and age, together with gender * age, significantly affected the PEE measure (F (1, 652) = 11.440, $p < 0.017$, $\eta^2 = 0.017$; F (2, 652) = 28.360, $p < 0.001$, $\eta^2 = 0.08$; and F (2, 652) = 4.843, $p < 0.017$, $\eta^2 = 0.015$, respectively). Female students (M = 3.89, SD = 0.69) scored significantly higher than male students (M = 3.73, SD = 0.84) in PEE. All students with lower grade levels scored significantly higher than students with higher grade levels in PEE (Mean Difference [primary school–middle school] = 0.31, 95% confidence interval = 0.173 to 0.447, $p < 0.001$; Mean Difference [middle school–high school] = 0.21, 95% confidence interval = 0.071 to 0.35, $p = 0.01$).

Simple effect analysis was conducted following the significant joint effect of gender * age, which further revealed the interaction on PEE. Among primary and high

school students, females tended to have significantly higher PEE than males (Mean Difference = 0.24, 95% confidence interval = 0.046 to 0.44, $p = 0.016$; Mean Difference = 0.38, 95% confidence interval = 0.182 to 0.585, $p < 0.001$). Among male students, primary and middle school male students had significantly higher PEE than high school male students (Mean Difference = 0.61, 95% confidence interval = 0.371 to 0.842, $p < 0.001$; Mean Difference = 0.43, 95% confidence interval = 0.182 to 0.669, $p < 0.001$). While among female students, primary school students showed higher PEE than middle and high school students (Mean Difference = 0.47, 95% confidence interval = 0.229 to 0.704, $p < 0.001$; Mean Difference = 0.47, 95% confidence interval = 0.215 to 0.717, $p < 0.001$).

The main effect of grade level on SI was also statistically significant ($F(2, 652) = 21.860$, $p < 0.001$, $\eta^2 = 0.063$). Students at the high-grade level scored significantly higher than students at the primary-grade level (Mean Difference = 0.528, 95% confidence interval = 0.376 to 0.679, $p < 0.001$). The students at the middle-grade level scored higher than the students at the high-grade level (Mean Difference = 0.197, 95% confidence interval = 0.431 to 0.351, $p = 0.037$). However, the main effect of gender on SI was not significant ($F(1, 652) = 8.129$, $p > 0.001$).

Discussion

The research problem presented in this study has been satisfactorily clarified and is able to demonstrate that students intend to use tablets for mobile learning. This study examined gender and age differences among Chinese K-12 students in their acceptance of TBL. Results indicated that there were significant gender and age differences in the acceptance of TBL among K-12 students. Females showed significantly higher TBL acceptance levels than males, which was contrary to the previous research results in other regions. Boys were more willing to accept TBL, while girls insisted on using traditional methods (Abidin et al., 2018; Vale & Leder, 2004; Villani et al., 2018). This might show the well behaved image of Chinese K-12 girls, who place more emphasis on learning, while boys are more rebellious. In addition, Primary school students and middle school students were displayed significantly higher TBL acceptance levels than high school students. This is also contrary to the previous research (Nikolopoulou, 2018), which probably could be explained older students have been widely exposed to tablets in social life. Follow-up results showed that both primary and middle school students scored significantly higher levels of acceptance than high school students within the male group. Perhaps it is because younger boys are more interested in TBL. Female-high school students tended to have significantly higher levels of acceptance of TBL than their male counterparts. However, previous studies showed that there was no such difference (Dündar & Akçayır, 2014; Cacciamani et al., 2018). Perhaps in high school, girls are more proactive in their studies than boys.

Therefore, it is worth considering how to further stimulate high school students, especially high school boys', acceptance of TBL. Firstly, the interactivity and gamification elements of TBL can be increased due to boys' higher interest in games and competitions, such as online competitions, point incentives, and virtual rewards.

Secondly, set more challenging goals for boys, especially older high school boys. Because boys are often more interested in challenging tasks, Finally, collaborative learning supported by tablets might also be beneficial. Encourage students to engage in group collaborative learning through online communication and collaboration tools supported by tablet devices, which is beneficial for those boys who like interacting with others.

Furthermore, this study extended current research by exploring factors that influence student acceptance of TBL, as well as gender and age differences in these factors. PEE, SI, and TSEPS are determined to be main factors influencing the intention of Chinese K-12 students to use mobile learning. Given the limited focus of previous studies on exploring the factors that affect K-12 students' acceptance of TBL, this represents a unique contribution to integration research on tablets in K-12 education, not only in China but also in the Asia-Pacific region and developing countries. Additionally, this study also confirmed the existence of some obvious gender and age differences in determining factors affecting acceptance. Female students scored significantly higher than male students in PEE. Previous research showed mixed results regarding whether there are gender or age differences in users' PE and EE toward innovative technologies. Some studies suggested that PE had a greater impact on TA for males, as they tended to be highly task-oriented and more proactive in accepting technology (Meelissen & Drent, 2008). However, other researchers argued that there were no gender differences in PE or EE related to TA, which was a stereotype that using technological tools to improve work performance was a male-oriented activity (North & Noyes, 2002). The findings of this study differed, as female students tended to have higher PEE than male students. This can be explained by the fact that, in the context of this study, female students may be more inclined to focus on improving their learning efficiency (Arroyo et al., 2013). As some researchers said, "good girls" work hard and perform well (Reay, 2001).

This study also confirmed the age differences in PEE and SI among K-12 students. Students with lower grade levels scored significantly higher than students with higher grade levels in PEE. Some scholars believed that younger students were more willing to use technology in their learning than older students (Ferguson, 2016; Yilmaz, 2016). This can be understood as a novelty effect, which is a common phenomenon in many technological innovations (Clark, 1983). As time goes by, the excitement about innovative technology will diminish, replaced by boredom, especially when users do not see the benefits of technology (Clark, 1983). Moreover, older students often find learning boring and have lower motivation than younger students (Ferguson, 2016). In addition, another interesting finding of this study was that there were age differences in SI, but no gender differences were found. Firstly, age differences were found in SI among K-12 students, with middle school students scoring higher than high school students, and high school students scoring significantly higher than elementary school students. Related research has shown that adolescents in middle adolescence have higher levels of peer conformity than those in early or late adolescence (Brown, 1990; Steinberg & Monahan, 2007). This could provide psychological evidence that middle school students in early and middle adolescence may be more influenced by their peers in TBL than elementary and high school students. Secondly, previous research has shown that SI is a stronger determinant of women's technology

usage intention than men's, which may be due to the fact that female students prefer to interact with their close friends (Venkatesh et al., 2003; Yu et al., 2018). However, the results of this study contradict previous research, as no gender differences were found in SI among these students. This could be attributed to the fact that, in the context of this study, both male and female students may be all influenced by their peers in TBL in the same digital environment (Wang et al., 2009).

Hence, several suggestions have been proposed. Firstly, students' performance expectancy of TBL needs to be enhanced in China's K–12 education, especially for boys and senior students. For example, clearly demonstrate the benefits of TBL, such as improving learning efficiency and facilitating access to abundant resources. It can also be done to show how to effectively learn using tablets through examples, including sharing success stories. This is an issue that policymakers need to consider for promoting TBL in China's K–12 education. Secondly, the effort expectancy of TBL needs to be reduced, especially for girls and junior students. For example, ensure that the tablet interface is user-friendly and easy to navigate, reducing the difficulty of learning new technology, which is a point that tablet developers need to focus on. Detailed usage guides and training can also be provided to help students get started quickly. In addition, gradually cultivate K–12 students' technical self-efficacy for problem-solving. Students with high levels of technical self-efficacy for problem-solving will easily benefit from TBL, but for those with low levels, there may be certain obstacles. Teachers can design tasks and challenges with gradually increasing difficulty in TBL, allowing students to gradually build confidence in the process of solving problems. Finally, gradually expand the social influence of TBL, especially for elementary school students. Positive communication could be encouraged between teachers and students, sharing experiences and tips for tablet learning. Student leaders or students with greater influence can be utilized as positive examples of tablet learning to motivate other students to follow suit.

Conclusions

This study addressed a research gap in the acceptance of TBL among K-12 students in China by examining gender and age differences as well as the influencing factors. Overall, females showed significantly higher TBL acceptance levels than males. Primary school students and middle school students displayed significantly higher TBL acceptance levels than high school students. In detail, age differences within the male student group, where primary and high school students demonstrated higher acceptance rates of TBL compared to junior high school students. Female high school students tended to be more acceptable to tablet-based learning, with no significant gender differences observed at other stages. In addition, PEE, SI, and TESPS were important determinants of K-12 students' acceptance of TBL. There were age and gender differences in PEE. Only age differences were found in SI among these students. These findings hold significant implications for the design and implementation of TBL in K-12 schools in developing countries.

Firstly, policy makers and schools should make some plans to help students overcome any internal barriers to TBL by considering students' acceptance levels and related determinants (PEE, SI, TSEPS). Secondly, school administrators and teachers should

consider how to design a new type of TBL based on students' age and gender differences in acceptance and these key factors. In detail, boys and high school students need to be motivated more to be engaged with TBL, especially high school boys. In addition, technology developers should focus on the educational functionality, user-friendliness, and more personal content presentation of tablet learning applications according to the age and gender difference in acceptance and these significant determinants (PEE and SI) of TBL. Perhaps developing tablet devices with powerful social functions, low effort expectations, and high PE will have great competitiveness in the Chinese market. Additionally, this study contributes important theoretical insights regarding K-12 education in China. The study expanded the existing UTAUT framework by including TSE, merging PE and EE into UTAUT, and carefully integrating these constructs into the existing structure of UTAUT. Notably, the new construct, TSE, was significant across all respondents. These results provide valuable insights for researchers. In addition, Schools should note that if students have high digital literacy and TSE, their primary concern is how tablets can help solve learning problems rather than technical issues related to tablets. Therefore, once students are familiar with the technology, schools should shift their focus from technical training to training on using tablets to solve learning problems.

Limitations and future work

This study has some limitations that can be addressed in future research. Firstly, although the participants have extensive experience with TBL, the sampling method may be biased as all participants were from the same region. Future research will involve participants from more diverse geographic areas to make the results more generalizable. Cross-cultural differences in TBL is worth studying. Secondly, this study is based on self-reported data, which may introduce potential biases. More objective Multimodal behavioral data in TBL may be utilized to comprehensively explain students' acceptance in the future. Thirdly, this study is a cross-sectional study only measuring participants' views at one point in time. Future research may focus on the sustained acceptance of TBL by K-12 students, which might provide deeper insights. The framework for sustained acceptance may need to be rebuilt. In addition, the differences in age and gender regarding the acceptance of TBL have only been revealed, while other differences such as location (rural or urban) and learning style are also worth paying attention to. Finally, other variables could to be added to UTAUT to explain the behavioral intention of mobile learning (Hameed et al., 2022). For example, the learning value variable proposed by Ain et al. (2016) as students' perceptions that time and effort put into learning can be added to the UTAUT framework to explore their relationships with acceptance of TBL. Despite these limitations, this study is valuable as it provides informative experiential insights into TBL for K-12 schools and policymakers in China, the Asia-Pacific region, and developing countries.

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Ethical declarations

Conflict of interest The authors declare that they have no conflict of interests.

Ethical statement We confirm that this manuscript is a product of our original work. This manuscript does not include any previously published or authored research. We are the sole authors of this manuscript, and we accept full legal responsibility for the accuracy and completeness of this statement.

Informed consent This study has obtained the informed consent of the all participants.

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