The relationship between technology acceptance and self-regulated learning: the mediation roles of intrinsic motivation and learning engagement

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Abstract

The current study assessed 495 middle school students in China using self-report questionnaires, to examine the multiple mediating effects of intrinsic motivation and learning engagement (vitality, dedication and absorption) in the relations between technology acceptance and students' self-regulated learning. The results indicated that technology acceptance had a significant impact on self-regulated learning, intrinsic motivation mediated the relations between technology acceptance and self-regulated learning, and learning engagement (vigor, dedication, and absorption) mediated the relations between technology acceptance and self- regulated learning. The findings suggested that students' perceived acceptance of technology can help them improve their ability to engage in self-regulated learning by enhancing intrinsic motivation and increasing learning engagement. The results expand our understanding of self-regulated learning for Chinese middle school students in the context of information technology, and have substantial theoretical and practical implications for educator and relevant researchers.

Keywords Technology acceptance · Self-regulated learning · Mediation · Intrinsic motivation · Learning engagement

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1 Introduction

It is well known that self-regulated learning is one of the most critical competencies for lifelong learning and success in the 21st century (Commission of the European Community, 2000; Skinner et al., 2015; Anthonysamy et al., 2020). Self-regulated learning ability of learners helps to improve individual's academic performance and further academic achievement (Van Den Hurk, 2006; Mega et al., 2014; Broadbent & Poon, 2015). With the development of information technology and the rise of artificial intelligence, massive online videos and open courses provide students with good conditions for self-regulated learning (Azevedo & Cromley, 2004; Kizilcec et al., 2017; Wong et al., 2019). At the same time, online learning also puts forward higher requirements on students' self-regulated learning skills (Howland & Moore, 2002; Barnard et al., 2009; Whipp & Chiarelli, 2004; Tsai et al., 2013). Previous studies have found that the success of online learning depends on the acceptance of new technologies (Chang & Tung, 2008; Sun et al., 2008; Li et al., 2012). Students' acceptance and application of technology in online learning have become the key factors affecting their self-regulated learning (Liaw & Huang, 2013; Zheng & Wang, 2020; Chang et al., 2016). However, the dynamic relationship between technology acceptance and students' self-regulated learning remains unclear.

Previous studies have attempted to propose frameworks or models to explain the relationship between the technology acceptance model and self-regulated learning (Zhu et al., 2020), most of which have found a positive relationship between them. According to the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2012), students' willingness to accept technology can promote their positive learning behaviours (Acikgul & Sad, 2021). Social motivation theorists believe that students building strong motivational beliefs will motivate them to apply more learning strategies (Bai & Wang, 2021) and improve self-regulated learning (Yukselturk & Balut, 2009; Ocak & Yamac, 2013; Tanriseven & Dilmac, 2013). Positive learning engagement is the external manifestation of motivational adjustment and contributes to positive self-regulated learning (Alemayehu & Chen, 2021; Sha et al., 2012). That is, we hypothesized that technology acceptance may be related to learning motivation and learning engagement which, in turn, is associated with self-regulated learning.

However, few studies have verified the relationship between technology acceptance, learning motivation, learning engagement, and students' self-regulated learning in a range of multiple mediation models. In addition, most previous studies reporting the relevance of self-regulated learning among students have been conducted in Western cultural contexts (Perry et al., 2006; Heikkila & Lonka, 2006; Theobald, 2021) and college student groups (Zheng et al., 2018; Dorrenbacher & Perels, 2016; Wolters & Hussain, 2015). Therefore, we investigated the relationship between technology acceptance, learning motivation, learning engagement, and self-regulated learning among Chinese middle school students, as research by different cultures and groups may help expand the theory of self-regulated learning.

2 Literature review

2.1 Technology acceptance and self-regulated learning

Technology acceptance, that is, how technology emerges and is adopted (Joo et al., 2018; Cheung & Vogel, 2013), has been studied using various theories (Mathieson, 1991; Ajzen, 1991; Pavlou & Fygenson, 2006) and models (Davis, 1989; Venkatesh & Thong, 2012; Venkatesh & Bala, 2008). Today the Technology Acceptance Model (TAM) (Davis, 1989) is considered the most dominant model for investigating the factors that influence user acceptance of technology (Sun et al., 2008; Hsu et al., 2018). The TAM technology acceptance model was based on the Theory of Planned Behavior (TPB) (Ajzen, 1991; Pavlou & Fygenson, 2006) and was originally proposed by Davis (1989). It sets perceived usefulness and perceived ease of use as antecedent variables that affect users' attitudes toward information technology, directly affecting their attitudes toward technology use, and indirectly affecting actual use behavior (Davis, 1989; Lee & Lehto, 2013). Technology acceptance as the most influential and commonly used theory to describe the individual's acceptance of information systems and technology (Scherer et al., 2018). This acceptance not only provides individuals with favorable information or feedback loops to control their use of technology, but also leads to their self-regulation of technology learning (Lai, 2013). More specifically, in the post-COVID-19 context, learners inevitably embrace technology and use it (Vargo, 2021; Yan, 2021), which forces them to engage in self-regulated learning (Pelikan et al., 2021).

Self-regulated learning was defined by Zimmerman (2008) as "learning in which students choose and apply self-regulated learning strategies based on feedback on learning efficiency and learning skills in order to achieve the desired learning outcomes". In other words, self-regulated learning is an ability that refers to the ability of learners to set goals in the learning process and use metacognition, motivation, and behavior strategies to plan, monitor, regulate, and reflect on their own learning process and behavior (Rodrigues et al., 2019). It is also seen as a learning style that emphasizes learners to actively motivate themselves and actively use appropriate learning strategies. Studies have shown that self-regulated learning has a significant impact on students' academic achievement (EI-Adl & Alkharusi, 2020). Students with high self-regulation learning level have good cognitive and metacognitive strategies, can make full use of external resources in the learning process, constantly monitor the distance from the goal, maintain a high level of learning efficacy, and effectively solve problems (Popham et al., 2020). In addition to this, self-regulation learning is a cyclical process that affects an individual's cognitive development ability (Eissa, 2015). Additional studies have shown that an individual's self-regulation learning is mostly influenced by the operating environment (Wan et al., 2012). A study showed that in blended learning environments, technology acceptance has a positive effect on students' self-regulated learning (Zhu et al., 2020). In informal learning settings, such as after the COVID-19, learners' willingness to accept technology and behavioral changes in their use require more proactive and self-regulation. In this case, learners must formulate the timing, pace, and strategy of their own learning process. Considering that technology acceptance involves learners' more active self-regulated

learning ability (Nuankaew et al., 2019), therefore, in this study, we hypothesized that technology acceptance was positively correlated with students' self-regulated learning.

2.2 Technology acceptance, learning motivation and self-regulated learning

Learning motivation is one of the significant factors closely related to self-regulated learning (Finn, 2021; Radovan, 2011). Learning motivation can stimulate and sustain learners' learning behavior and play a vital role in self-regulated learning (Karlen, 2016). The higher the learners' motivation level, the more actively they use self-regulation strategies to facilitate learning (Aguilar et al., 2021). Self-determination theory (SDT) (Deci & Ryan, 2008a, b) held that people were active organisms, constantly driven by the need to develop their personal potential, striving to meet various challenges to promote the psychological growth. The theory emphasized the intrinsic and self-deterministic nature of motivation, arguing that the source of motivation was the innate need of individuals to realize their own potential (Deci & Ryan, 2008a, b; Vansteenkiste et al., 2020). In SDT, motivation can be intrinsic or extrinsic (Vansteenkiste & Lens, 2006). Thus, the self-determination theory lays the theoretical foundation for the motivational process of students' self-regulated learning behaviors.

Previous research had shown that students who were more motivated to learn will be motivated to use more learning strategies and improve their cognitive abilities (Paulsen & Feldman, 2007). And the students will display greater self-regulated learning through behavioral performance necessary to achieve specific academic goals (Abar & Loken, 2010). A study has been suggested that students' motivation may also have a weakened motivation to learn online if their willingness to use technology is negatively affected in an online learning environment (Clayton et al., 2010). Kashive (2022) found that if students perceived the usefulness and ease of use of digital learning platforms, their motivation to learn will be improved. Previous studies had demonstrated that learning motivation was associated with technology acceptance (Zuo et al., 2021; Maldonado et al., 2011) and self-regulated learning among students (Zheng et al., 2018). Thus, in this study, we hypothesized that learning motivation played a mediating role between technology acceptance and self-regulated learning.

2.3 Technology acceptance, learning engagement and self-regulated learning

Studies have shown that there is a close relationship between learning engagement and self-regulated learning (Romero et al., 2020; Torenbeek et al., 2013). Learning engagement is a continuous, positive emotion state of performance towards learning, characterized by vigor, dedication and absorption (Schaufeli et al., 2002). Many studies have validated that learning engagement is one of the important predictors of learning quality and academic achievement, which is critical to adolescent educational success (Wang & Hofkens, 2020; Zheng et al., 2020). Previous studies have explored the influencing factors of learning engagement from the perspectives of academic performance, academic emotions, and academic anxiety (Chung et al., 2017; Malczyk and Lawson, 2017). In addition, Leon (2015) has suggested that students

who make greater use of deep cognitive strategies in their learning are more engaged in their learning, which can predict levels of self-regulated learning. Positive learning engagement can help individuals actively seek out learning opportunities and resources and develop greater perseverance and effort, which can make students feel more focused on learning and thus lead to self-regulated learning behaviors in individuals (Stephenson & Isaacs, 2019). Therefore, students' learning engagement is closely related to their learning behavior and is an important factor influencing self-regulated learning.

Studies on technology acceptance and learning engagement have found that technology acceptance has a significant positive correlation with students' learning engagement. This indicates that the better students' perception of technology in an online learning environment, the easier it is for students to actively participate in classroom learning. Therefore, in this study, we hypothesized that learning engagement could mediate the relationship between technology acceptance and self-regulated learning.

2.4 The present study

We proposed a dual mediation model based on the above literature. Previous studies have shown that technology acceptance is associated with self-regulated learning, and that learning motivation and learning engagement may play a mediating role. Therefore, the current study filled in the gaps in the literature by attempting to explore the mediating effects of learning motivation and learning engagement on the relationship between technology acceptance and self-regulated learning, and proposed the following assumptions:

Hypotheses 1(H1) Technology acceptance has a direct and positive impact on self-regulated learning.

Hypotheses 2(H2) Learning motivation mediates between technology acceptance and self-regulated learning.

Hypotheses 3(H3) Learning engagement mediates between technology acceptance and self-regulated learning.

3 Method

3.1 Participants and procedures

The data in the current study were collected from 495 students from a middle school in western China. In this study, to reduce the effects of homologous bias, we surveyed participants at two time points in the middle of the semester. The interval between two time points was 2 weeks. We measured technology acceptance and self-regulated learning at the first time point, and measured learning motivation and learn-

ing engagement at the second time. In the first survey, a total of 515 questionnaires were distributed, and 506 valid questionnaires were recovered, with a recovery rate of 98.25%. In the second survey, 5 students took leave, and after excluding these 5 students, a total of 510 questionnaires were distributed, and 510 questionnaires were recovered, with a recovery rate of 100%. Excluding invalid questionnaires such as answer time < 180s, logical errors in verifiable questions, and filling in the same answers for more than 90% of the questions, 495 sets of effective questionnaires were obtained, and the effective return rate was 96.12%.

On average, the participants were 13.20 years old (SD = 0.691) and the age ranged from 12 to 15 years; 242 (48.90%) were boys and 253 (51.10%) were girls. 255 students were in seventh grade (51.50%), and 240 students were in eighth grade (48.50%). We did not evaluate middle school students in Grade 9 because they were busy preparing for the high school entrance exam. This study was approved by the Research Ethics Committee of Jinghengyi College of Education of Hangzhou Normal University and the principals of participating schools. The data collected in this study was anonymized to protect the privacy of participants.

3.2 Measuring instruments

3.2.1 Technology acceptance

Technology acceptance was measured using a revised research questionnaire (Teo, 2009) of the Technology Acceptance Model (Davis, 1989). The TAM model has successfully demonstrated appropriate concurrent and construct validity in the Chinese environment. The questionnaire uses a self-report scale to assess students' perceived technology acceptance from four perspectives: perceived usefulness (3 items, e.g., "Using computers will enhance my effectiveness"), perceived ease of use (3 items, e.g., "I think it's easy to use a computer"), attitude towards using (3 items, e.g., "I like using computers") and behavioral intention (3 items, e.g., "I plan to use computers to study in the future"). All items were rated on a 5-point Likert scale with a range from 1 (completely disagree) to 5 (completely agree). Therefore, as an indicator of technology acceptance, the higher score indicates, a higher level of technology acceptance. In this study, the Cronbach's alpha value was 0.941 and the fitting of the validation factor analysis were adequate [χ^2/df = 2.98, CFI = 0.946, TLI = 0.935, RMSEA = 0.071, SRMR = 0.050].

3.2.2 Learning motivation

Students' learning motivation was assessed using the revised Chinese version of the Learning Motivation Scale (Chi & Xin, 2006). Developed by Amabile (1994), the revised scale was suitable for Chinese students and included both intrinsic motivation (14 items, e.g., "I like to think independently to solve problems") and extrinsic motivation (16 items, e.g., "I am very clear about my goals or goals to achieve good grades"). Each item was rated on a 5-point Likert scale with a range from 1 (completely disagree) to 5 (completely agree). Therefore, as an indicator of learning motivation, the higher the score, the stronger the motivation to learn. In this

study, the Cronbach's alpha value was 0.882, and the validation factor analysis (CFA) showed the acceptable fitting index of the modified scale [χ^2/df=3.17, CFI=0.924, TLI=0.932, RMSEA=0.073, SRMR=0.041].

3.2.3 Learning engagement

The learning engagement scale adapted by Fang et al. (2008) was used to assess students' perception and judgment of their own learning engagement. This scale was a translation and revision of the Learning Engagement Scale developed by Schaufeli et al. (2002) and was suitable for Chinese middle school students. The scale consists of three dimensions, including vigor (6 items, e.g., "I feel energetic when I study"), dedication (5 items, e.g., "I find learning challenging"), and absorption (6 items, e.g., "I am immersed in learning"). Each item was rated on a 5-point Likert scale with a range from 1 (completely disagree) to 5 (completely agree). In this study, the Cronbach's alpha value was 0.947. Fittings for factor analysis with good validation were also available [χ^2/df=3.24, CFI=0.953, TLI=0.937, RMSEA=0.075, SRMR=0.047].

3.2.4 Self-regulated learning

Self-regulated learning was measured using an adaptive version of the Self-Regulated Learning Scale (Pang, 2003). It has a high degree of homogeneity and internal consistency among Chinese adolescents, with a Cronbach's alpha of 0.929. The self-regulated learning scale consists of 60 items that reflect students' attitudes towards self-regulated learning and includes six dimensions: self-regulation in learning content (12 items, e.g., "I often make study plans for myself"); time management (8 items); learning strategies (17 items); learning process (6 items); assess and enhance learning outcomes (8 items); and control the learning environment (6 items). Each item was scored on a 5-point scale, ranging from 1 (totally disagree) to 5 (totally agree). The higher the score, the greater the ability to engage in self-regulated learning. In this study, the Cronbach's alpha value was 0.976. Validating Factor Analysis (CFA) indicates the acceptable fitting index of the modified scale [χ^2/df=3.15, CFI=0.962, TLI=0.945, RMSEA=0.069, SRMR=0.044].

3.3 Data analysis

Descriptive analyses were conducted for all measures involved. Pearson correlations were calculated to examine the associations among the main variables. t-tests and ANOVA were also used to explore potential differences of gender and grade in self-regulated learning. Then, we used Mplus 8.3 software (Muthén & Muthén, 1998–2017) to build structural equation models. Missing data were handled by using maximum likelihood estimates (ML) in the structural models.

We further investigated the multiple mediating effects of learning motivation (intrinsic and extrinsic motivation) and learning engagement (vigor, dedication and absorption) on the relationship between technology acceptance and self-regulated learning using a two-step procedure. First, we built a direct effect model to assess

the direct effect of technology acceptance on self-regulated learning. Second, based on the direct effect model, we inserted mediators (e.g., intrinsic/extrinsic motivation, vigor, dedication, and absorption) between technology acceptance and self-regulated learning, and added predictive paths. Therefore, the multiple mediating effects model was formed (see Fig. 1). The chi-square values, the comparative fit index (CFI), Tucker-Lewis index (TLI), the root mean square error of approximation (RMSEA) and the standardized root mean square residual (SRMR) were used to evaluate model fit. A non-significant chi-square indicates good model-data fit. The general cutoffs for accepting a model are equal to or >0.90 for CFI and TLI, and equal to or <0.08 for the RMSEA and SRMR (Wen et al., 2004). Moreover, to test the statistical significance of this indirect effect, we conducted bias-corrected bootstrap tests with a 95% confidence interval (MacKinnon et al., 2004).

4 Results

4.1 Descriptive statistics and correlations among main measures

Descriptive characteristics and correlations among all measures are displayed in Table 1. The mean levels of technology acceptance, intrinsic motivation, extrinsic motivation, vigor, dedication, absorption and self-regulated learning were 3.71, 3.31, 3.85, 3.27, 3.77, 3.53 and 3.80, respectively. The results showed that there was a significant positive correlation among all these variables.

In addition, t-tests and ANOVA were applied to assess gender, age and grade differences in self-regulated learning among middle school students. We found that there was no significant gender difference (t=2.164, $p=0.739$) and grade difference (t=2.084, $p=0.432$). However, age was found to have significant positive relation with self-regulated learning (F=5.809, $p<0.001$). Post-hoc tests found that 12 years old had higher levels of self-regulation than 13 years old (Significant, $p=0.004$), and 13 years old had higher levels of self-regulation than 14–15 years old (Significant, $p=0.014$).

4.2 The mediating effects of learning motivation and learning engagement

We examined the multiple mediating effects of learning motivation (intrinsic and extrinsic motivation) and learning engagement (vigor, dedication and absorption) in the relation between technology acceptance and self-regulated learning using the two following steps.

4.2.1 Analysis of direct effect model

Using Mplus8.0 software, we explored the direct impact of technology acceptance on self-regulated learning. The results showed that after controlling for gender and age, the model fitting of the technology acceptance for self-regulated learning was acceptable [$\chi^2/df=3.87$, CFI=0.995, TLI=0.963, RMSEA=0.072, SRMR=0.030]. It was

Table 1 Mean (M), standard deviation (SD) and correlations for the main variables

| Variables	M±SD	1	2	3	4	5	6	7	8	9
1. Gender	-	-								
2. Age	13.20±0.29	0.067	-							
3. Technology acceptance	3.71±0.84	-0.071	0.161**	-						
4. Intrinsic motivation	3.31±0.49	-0.016	0.082	0.285**	-					
5. Extrinsic motivation	3.85±0.51	-0.179**	-0.064	0.263**	0.350**	-				
6. Vigor	3.27±0.95	-0.192**	-0.054	0.131**	0.181*	0.344**	-			
7. Dedication	3.77±0.88	-0.170**	-0.067	0.164**	0.146**	0.441**	0.693**	-		
8. Absorption	3.53±0.87	-0.128**	-0.070	0.169**	0.111*	0.401**	0.722**	0.777**	-	
9. Self-regulated learning	3.80±0.65	-0.097*	-0.052	0.209**	0.168**	0.539**	0.679**	0.700**	0.692**	-

Note: $*p < 0.05$; $**p < 0.01$

indicated that technology acceptance has a direct predictive effect on self-regulated learning ($\beta = 0.209$, $p < 0.001$).

4.2.2 Analysis of multiple indirect effects model

Next, after controlling for the gender and age variables, we added mediating variables (intrinsic motivation, extrinsic motivation, vigor, dedication, and absorption) to the above direct-effects model for structural equation model testing. The results showed that the multiple mediation-effects model established in this study fit well [$\chi^2/df = 2.94$, CFI $= 0.942$, TLI $= 0.965$, RMSEA $= 0.074$, SRMR $= 0.035$].

The model results found that when mediating factors (intrinsic motivation, extrinsic motivation, vigor, dedication, and absorption) were taken into account, the relationship between the independent variable (technology acceptance) and the dependent variable (self-regulated learning) remained significant ($\beta = 0.165$, $p < 0.001$). However, this coefficient was smaller than the first coefficient ($\beta = 0.165$ vs. 0.209), suggesting that learning motivation (intrinsic motivation) and learning engagement (vigor, dedication and absorption) were partially mediating between technology acceptance and self-regulated learning. In terms of mediating effects, technology acceptance had an indirect affect on self-regulated learning through the mediating variables of intrin-
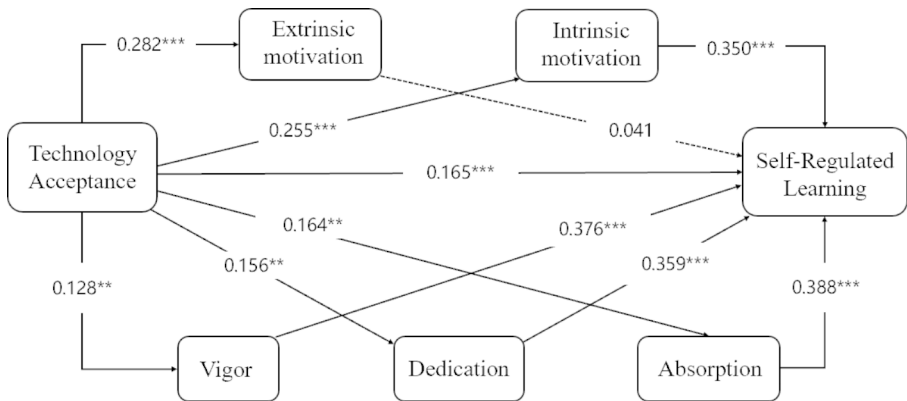
Fig. 1 The multiple indirect effects model after controlling for gender and age. The dashed lines represent that the predictive paths were non-significant. **p<0.01, ***p<0.001

Table 2 Bias-corrected bootstrap test on mediating effects

Paths	Standardized Estimate (β)	95% CI	
		Low	High
TA—SRL	0.165***	0.106	0.223
TA—EM—SRL	0.011	-0.020	0.036
TA—IM—SRL	0.089**	0.043	0.150
TA—VI—SRL	0.048***	0.006	0.118
TA—DED—SRL	0.056**	0.013	0.121
TA—AB—SRL	0.063**	0.016	0.137

Notes: TA=technology acceptance, EM=extrinsic motivation, IM=intrinsic motivation, VI=vigor, DED=dedication, AB=absorption, SRL=self-regulated learning

**p<0.01, ***p<0.001.

sic motivation, vigor, dedication and absorption, but extrinsic motivation cannot be used as a mediating variable. This also revealed that intrinsic motivation and learning engagement played multiple mediating roles between technology acceptance and self-regulated learning. A detailed model was shown in Fig. 1. The multiple indirect mediating effects model also fit the data well [χ^2/df=3.20, CFI=0.967, TLI=0.983, RMSEA=0.055, SRMR=0.041].

Furthermore, we conducted bias-corrected bootstrap tests to examine whether the indirect paths displayed in Fig. 1 were significant. As shown in Table 2, the 95% confidence interval of indirect paths from technology acceptance to self-regulated learning via intrinsic motivation, vigor, dedication, and absorption included 0, suggesting that after controlling for gender and age, except for the path from technology acceptance to self-regulated learning via extrinsic motivation, all other indirect paths were significant and the mediating roles were established.

5 Discussion

In the present study, a multiple indirect model was conducted to examine the relations among technology acceptance, learning motivation (intrinsic motivation and extrinsic motivation), learning engagement (vigor, dedication and absorption), and self-regulated learning in a sample of middle school students in China. The main findings of the current study were as follows :(1) there was a positive correlation between technology acceptance, learning motivation, learning engagement and self-regulated learning of Chinese middle school students; (2) intrinsic motivation mediated the relationship between students' technology acceptance and self-regulated learning; (3) learning engagement (vigor, dedication and absorption) mediated the relationship between students' technology acceptance and self-regulated learning. Overall, the current study provided empirical evidence for the relationship between students' willingness to accept and use of technology and learning behavior.

5.1 Technology acceptance and self-regulated learning

Our data analysis showed that technology acceptance was positively associated with self-regulated learning. This was consistent with previous research (Zhu et al., 2020). Self-regulated learning involves the ability to independently use an individual's cognition, motivation, and behavior to manage the learning process (Kim et al., 2020). Therefore, we can explain that students with high acceptance of technology will guide their self-regulated learning behaviors which, in turn, will have stronger self-regulated learning ability. This positive relationship may be due to the fact that students' perceived ease of use and usefulness of technology provided positive and profound learning experiences that enable them to actively engage in tasks, leading to the generation of self-regulated learning behaviors (Isha et al., 2021). In the current context of deep integration of information technology into education and teaching, and the impact of the global COVID-19 pandemic, students may consider using technology for learning (Jang, 2021). If students develop a positive attitude toward technology acceptance, the better their online learning experience is, the higher their self-regulation level in setting goals, making plans, and choosing strategies.

The most important finding of the current study was that there was a unique link between students' technology acceptance and self-regulated learning, through the mediating effects of students' intrinsic motivation and learning engagement, which may provide new insights into the relationship between technology acceptance and self-regulated learning. The present results echo previous studies documenting technology acceptance, technological self-efficacy, and self-regulated learning (Pan, 2020). The results provided additional empirical support for the relationship between technology acceptance and self-regulated learning.

5.2 The mediating role of intrinsic motivation

H2 was partially supported by our findings, which showed that only intrinsic motivation mediated the relationship between technology acceptance and self-regulated learning. Extrinsic motivation could not significantly predict self-regulated learning

in the relationship. This may be because self-regulated learning is an intrinsic need that emphasizes internal self-drive, while extrinsic motivation is unable to maintain persistent need fulfilment (Hu & Zhang, 2017). This was also supported by previous studies. For example, Plant and Devine (2009) argued that external motivation had a negative but insignificant effect on individual's intentions, while internal motivation had a significant positive effect.

Intrinsic motivation refers to the pleasure and satisfaction an individual gets from doing an activity (Ryan & Deci, 2001). For example, students are motivated to attend class because he or she finds it interesting and satisfying to study certain subjects. Social cognitive scholars have proposed that in Self-Concept Theory (Campbell, 1990; Campbell et al., 1996) holds that self-concept is an organic cognitive structure composed of values, emotions, attitudes, etc., that runs through individual experience and behavior. The individual needs to act in a way that preserves self-perception, so that self-perception will guide consistent behavior (Campbell et al., 2003). Therefore, students with stronger intrinsic motivation have stronger self-concept cognition, which will have a more direct impact on self-regulated learning (Saki & Nadari, 2018).

According to Ning and Downing (2012), students have different types and levels of motivation, and their successful learning experiences differ. The results were also consistent with self-determination theory (Deci & Ryan, 2008a, b). According to the theory, the need for self-regulation can guide individuals to perceive their own behavior as spontaneous and self-regulated. When choices were made with intrinsic motivation, the need for self-regulation was easily satisfied (Hong et al., 2009). According to the research, the influence of external motivation was the weakest among the self-determined motivational behaviors (Malhotra et al., 2008). This occurs when an activity is performed to satisfy an external need, gain a reward, or avoid punishment (for example, "I am taking classes to get credit"). Intrinsic motivation is a more controlled form of motivation that emerges when individuals begin to internalize the reasons for their behaviors, even if the source of motivation is primarily external (Mitchell et al., 2020). SDT (Deci & Ryan, 2008a, b) showed that individual internal factors, such as personal interests and curiosity, influenced a individual's motivation and further learning behavior. Therefore, based on these findings, the current study proposed that under the background of Chinese culture, it was more important to stimulate the intrinsic motivation of middle school students to improve their self-regulated learning.

5.3 The mediating role of learning engagement

Multiple mediation analysis also confirmed that the mediating effect of students' learning engagement between technology acceptance and self-regulated learning was significant. When students have a strong willingness to accept technology, they are more inclined to actively participate in learning, which further guides their self-regulated learning behavior. The findings were groundbreaking and provided further evidence of the relationship between technology acceptance and self-regulated learning in the context of Chinese middle school students with learning engagement as a mediator.

According to the Social Identity Theory (Ashforth & Mael, 1989), when learners have a higher degree of identification with their environment, they will show a higher level of immersion experience in the environment. For example, in an online learning environment, learners who perceived a positive technological learning experience in the classroom will be more motivated to learn and consistent learning, which will further enhance their learning engagement (Martin et al., 2018). Moreover, students' learning engagement further enhanced their belief in their ability to control their learning progress, which gradually lead to self-regulated learning behavior (Yu et al., 2020). In other words, students' strong engagement in learning can further stimulate intrinsic interest in learning and can promote effective and complex learning and cognitive strategies, which improving their self-regulated learning. These findings have implications for the practice of Chinese middle school students: students with strong willingness to accept technology are more willing to invest more energy in learning, thus inducing them to have stronger ability to engage in self-regulated learning. Under the background of in-depth integration of information technology into education and teaching, educators can improve students' self-regulated learning ability by paying attention to the influencing factors of learning engagement.

6 Conclusions, implications and future directions

Taking 495 middle school students in western China as a sample, the current study included learning motivation and learning engagement for the first time to investigate the comprehensive effect of technology acceptance on self-regulated learning, which enriched the theory of self-determination in the context of Chinese education. This study contributed to the self-regulated learning of middle school students in the following aspects.

First, we empirically examined the relationship between students' technology acceptance and self-regulated learning, which were mediated through intrinsic motivation and learning engagement. It provided literature expansion and empirical evidence for the complex relationships between hypothesized variables. Second, we used samples from the Eastern world to examine the above relationship, thereby extending Western theory to Eastern context. In Chinese educational practice, students need to internalize individuals' extrinsic motivation, and the improvement of individual's self-regulation largely depends on intrinsic motivation (Lee & Turner, 2017). At the same time, the stronger the intrinsic motivation of learning, that is, the higher the expected harvest for learning, the better the learning effect will be (Froiland & Worrell, 2017). Thirdly, this study also emphasized that teachers need to guide students to improve their participation in learning. For example, in the online environment, students perceived more technology usefulness and ease of use, and their confidence and beliefs will be strengthened, thus providing the possibility of students' learning engagement and promoting self-regulated learning. This also had some implication for the training of middle school students in China. Teachers can pay attention to students' learning engagement during the process of the technology acceptance and application, which will maintain a longer concentration on learning time, thus improving the self-regulated learning efficiency.

There are some limitations to this study. First, all variables in this study were measured by self-report scales without third-party observation, so future research could use various measures to improve the objectivity of the assessment. Second, the participants selected in this study were middle school students from a school in western China, so it should be carefully extended to other populations and other cultures. Future studies should consider samples from different cultural backgrounds, ages and educational backgrounds to enrich the scope of application. In addition, the influence from teachers and parents or peers was ignored in this study, so future research can consider these two factors in the extension of relevant research.

Data Availability The original data supporting the conclusions of this article will be provided by the authors without undue reservation.

Declarations

Conflict of interest No potential conflict of interest was reported by the authors.

Ethics approval The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of Jing Hengyi School of Education, Hangzhou Normal University, the Ethical Approval ID is 2,022,010.

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