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Exploring effects of intelligent recommendation, interactivity, and playfulness on learning engagement: An application of TikTok considering the meditation of anxiety and moderation of virtual reward

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ABSTRACT

The rise of short video applications such as TikTok has brought new opportunities to maximize student learning experiences in online learning environments. Meanwhile, literature that explores its potential to foster student engagement is scarce. To understand the effect of short video applications on students' learning engagement, we take Douyin (the Chinese version of TikTok) as an example to include user experience variables (i.e., playfulness, satisfaction, anxiety) and technology features variables (i.e., interactivity and virtual reward). Five hundred-two valid questionnaire responses were collected from Chinese undergraduates. Data were analyzed using Partial Least Squares Structural Equation Model (PLS-SEM) to test the hypothesis. Overall, learning anxiety has a negative effect on learning engagement, whereas learning satisfaction has a positive effect. Virtual reward has a negative moderating effect on the relationship between interaction and anxiety. Still, it positively moderates the relationship between satisfaction and learning engagement. In addition, both years of using a mobile phone and TikTok positively influence learning engagement. Collectively, the proposed model was supported and provided empirical evidence regarding the importance of user experience and product features (such as Intelligent recommendation and virtual reward) on student engagement. Implications for theories and teaching practice and limitations were discussed.

1. Introduction

The concept of engagement is intriguing because it is adaptable and sensitive to changes in instructors' practices, and because it has the potential to address educational difficulties such as low achievement and a high dropout rate (Fredricks et al., 2016; Caspari-Sadeghi, 2022). Engagement was thus a primary focus of interventions and a stated objective of numerous school reform programs (Appleton et al., 2006; Hamid et al., 2022). Furthermore, research suggests that the communication gap between educators and millennials still exists, as students have changed dramatically in recent years (Sayaf et al., 2022). In light of the COVID-19 epidemic, teaching and learning experiences in higher education have also evolved. One example is that online teaching has become routine, and numerous virtual learning platforms are being investigated (Heyang & Martin, 2022). As a result, studies are examining the possibility of maximizing engagement via social media platforms such as Facebook and Twitter (e.g., Dragseth, 2020; Junco, 2012). Recently, the educational function of technology and social media has risen dramatically during the COVID-19 pandemic (Matsiola et al., 2022; Conceição, 2022), partly because digital tools let teachers continue classes (Al-Maroof, Salloum, Hassanien, & Shaalan, 2020; Kovacs et al., 2022) through Emergency Remote Learning (ERL).

Short video applications, especially youth-focused platforms like TikTok (Vaterlaus & Winter 2021), can shed light on teenage experiences during the epidemic, including their impressions of online learning (Literat, 2021). TikTok has earned significant recognition as an instructional tool encouraging students' creativity and academic engagement (Escamilla-Fajardo et al., 2021; Fraticelli et al., 2021). To the best of our knowledge, current research on this area is limited despite its popularity and enormous promise for maximizing student engagement. Earlier studies on online-learning experience have related it to positive feelings about the system's ease of use and usefulness

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(Purnomo & Lee, 2013). However, knowledge about using social media to increase student engagement and the complicated relationships between negative emotions such as learning anxiety, technology features such as virtual reward and intelligent content recommendation, and student engagement appears to be lacking. Moreover, despite the affordance of resources and tools available for teaching and learning, there has been a dearth of research investigating the educational potential of platforms such as TikTok (Heyang & Martin, 2022). To date, the pedagogical potentials of TikTok have been manifested in several recent works (e.g., Escamilla-Fajardo et al., 2021; Heyang & Martin, 2022; Solomon, 2021). This study seeks to understand the impact of TikTok on the learning engagement of university students from the perspectives of user experience and technology features. Understanding students' learning engagement with TikTok is important for at least two reasons. First, TikTok is one of those apps which has experienced a significant breakthrough during the COVID-19 pandemic (Escamilla--Fajardo et al., 2021; Hartung et al., 2022), yet few studies have explored its impact on student engagement. Second, the importance of online education after Covid-19 will be considered for a few more years (Dorn et al., 2020). Exploring the educational potential of social media can provide educators and researchers with insights on how to engage students more effectively during times of crisis and for future opportunities to engage students. Third, to mitigate the learning loss due to school disruptions, there is an urgent need for a model/solution on how low-cost educational technology (such as TikTok) could engage students and improve learning performance (Angrist et al., 2022).

The organization of this work is as follows: initially, the context and relevance of the study are discussed, followed by the research hypothesis and a literature evaluation. The third section discusses the study's methodology and findings. We conclude by discussing the results, limitations, and directions for future study.

2. Literature review and research model

2.1. Learning engagement and social media applications

In recent years, research on student engagement has gained increased interest due to its potential to address educational challenges such as low achievement and a high dropout rate (Fredricks et al., 2016; Yang et al., 2018). Student engagement has been defined as commitment (Marks, 2000), participation (Kuh et al., 2007), or active participation in learning (Pekrun & Linnenbrink-Garcia, 2012; Reschly & Christenson, 2012). Furthermore, student engagement has been understood from multiple perspectives, such as behavioral, emotional, and cognitive components of engagement (Fredricks et al., 2004), and it can be directed toward learning (Carini et al., 2006) and technology (Henrie et al., 2015; Schindler et al., 2017; Bond & Bedenlier, 2019). Borrowing from the idea of Salmela-Aro and Read (2017), we characterized student engagement in this study as energy, devotion, and absorption in school.

Engagement has been studied in numerous educational contexts, including universities, schools, classrooms, and learning activities of varying lengths (Fredricks et al., 2016; Henrie et al., 2015). Studies have examined the relationship between Facebook (Junco, 2012) and Twitter usage and student involvement (Dragseth, 2020). The use of image and video-based social media to engage students in learning is a relatively recent phenomenon. Instagram, an image-based social networking platform, has been integrated into EFL (English as a Foreign Language) lessons (Prasetyawati & Ardi, 2020), sociology courses (Sakr, 2020), and science courses (Ganjoo et al., 2021). In addition, apps such as Snapchat have been implemented into higher education settings to assess their usefulness in promoting student engagement (e.g., Dobies & Nelson, 2016; Hurst, 2018). Although TikTok has been investigated in a few studies (Escamilla-Fajardo et al., 2021; Hayes et al., 2020; Jerasa & Boffone, 2021), to the best of our knowledge, no attempt has been made to evaluate its potential for encouraging student engagement in the online learning environment.

According to QuestMobile's semi-annual report, new users in China's short-form video industry (such as TikTok) were close to 100 million by June 2019 (Cortese, 2019). Based on a recent prediction, TikTok's global monthly active users will exceed 1 billion by 2022 (Yao et al., 2023). Among the TikTok users, 69.4% were youngsters aged 19 to 35 (QuestMobile, 2019). TikTok has overtaken Facebook as the app with the largest monthly usage in minutes in a short period (Scherr & Wang, 2021). As a result, scholars and educators worldwide started to think about how it can be utilized as a pedagogy tool to promote student engagement. For instance, applying a duoethnographic approach, Heyang and Martin (2022) reflected on their experience (as teachers) in using TikTok to support college-level dance teaching in both China and Norway contexts. The work of Solomon (2021) started by questioning how students perceive TilTok as a tool to support their well-being. He concluded that social media and classroom curriculum can function together to improve student engagement and socio-emotional well--being by building a connected community. One important takeaway is educators can use TikTok to help provide social and emotional support for students with a high level of anxiety. Meanwhile, Escamilla-Fajardo et al. (2021) present an educational innovation where TikTok is used as a pedagogical tool. The use of TikTok was associated with a higher levels of motivation, engagement and creativity, and curiosity among students. As a result, they recommend teachers use TikTok as a pedagogy tool for expressive and creative courses. To conclude, although several studies attempted to explore the potential of using TikTok as a pedagogy tool in educational settings, they often failed to model students' behaviors via both perspectives of user experience and technical features.

2.2. User experiences relevant to student engagement

A quality user experience emphasizing the positive aspects of interaction and usage may lead to further feelings of attachment, or engagement (Attfield et al., 2011). We identified several variables (including perceived playfulness, learning anxiety, and interactivity) that may impact student engagement in online learning environments.

Perceived playfulness was defined in this study as university students' subjective beliefs that participating in online educational activities will be rewarding and enjoyable (Wang & Huang, 2020). The importance of playfulness when providing online or hybrid learning experiences has been highlighted in several earlier works (Sarrab et al., 2016; Padilla-Meléndez et al., 2013). Playfulness has improved satisfaction, and both have been linked to users' intention to reuse (Balkaya & Akkucuk, 2021). Perceived playfulness was a driving force for social interaction in the instant messaging process (Hsieh & Tseng, 2017). Other studies also described playfulness as a vital feature of interaction design, such as in-game design (Arrasvuori et al., 2011; Deterding et al., 2011).

Learner satisfaction refers to a subjective assessment of a student's impressions of their involvement in an entire learning process, including positive, negative, and neutral assessments (Wang et al., 2021b). Alzahrani et al. (2017) described satisfaction as having three components: information satisfaction, system satisfaction, and overall satisfaction. According to Al-Rahmi et al. (2018), disparities in instructors' pedagogical and emotional engagement explained differences in students' satisfaction with the learning environment (Kangas et al., 2017). Furthermore, student satisfaction was significantly and positively associated with learning engagement (Rajabalee & Santally, 2021).

Learner anxiety as a negative emotion may affect academic performance and learning (Hilliard et al., 2020). We defined anxiety in this study as an unpleasant motivational state that is aroused by learning processes and is manifested in class (Amiri & Ghonsooly, 2015). Anxiety had a detrimental impact on learning outcomes and engagement and moderated additional learning motivation (Zhang et al., 2020). For example, Conrad (2002) discovered that online learners' initial anxiety negatively correlates with behavior engagement, and this anxiety level is relatively high among students with prior online learning experiences.

In addition to learning satisfaction and anxiety, interactivity (IN) has been found crucial in maximizing learning engagement. Interactivity is a communication process in which users have control and can converse with one another (Cheng, 2020). Interactivity in this study refers to students' subjective assessments of their participation in learning processes such as communication, discussion, and exchange (Pituch & Lee, 2006). Teachers can improve instructional results by boosting interaction (Liaw et al., 2007), and learners can have a better learning experience (i.e., learner satisfaction) if they interact more in the learning process. The quantity of interaction substantially impacted students' satisfaction with distance learning (Abdous & Yen, 2010). Furthermore, student engagement was negatively linked to learning anxiety (Lin et al., 2017). Chang and Lin (2019) discovered that an interactive response system (IRS) increased students' willingness to speak and decreased learning anxiety.

2.3. Product (technical) features that affect student engagement

Several novel features are key to the success of learning tools. For example, intelligent recommendation (IR) is one of the fundamental features in educational apps, such as digital libraries and course selection tools (Lin et al., 2018; Tawfik et al., 2020). In most cases, research on the potential of intelligent recommendation in an online learning environment is lacking. In the context of language education, students in intelligent recommendation system-enhanced groups reported greater levels of learner satisfaction (Hsu & Chang, 2013). Customer satisfaction is predicted by intelligent recommendation (Chen et al., 2010; Jiang et al., 2010). Moreover, user satisfaction in-game playing was found to be predicted by intelligent recommendation (Carvalho & Macedo, 2013, May). Meanwhile, intelligent recommendation was found to hold the potential to enhance interactivity. For example, Iglesias et al. (2013) designed a context-aware recommendation system to strengthen interactions with smart spaces. This intelligent recommendation would dynamically evolve depending on the learner's micro-service management patterns and context.

Virtual reward (VR) refers to digital or intangible incentives following the desired response to further reinforce the response (Zuckerman & Gal-Oz, 2014). The reward can be badges, points, digital tokens, or an extra game commodity. This study defined virtual reward in the TikTok community as the bonus and likes given by teachers to promote their learning engagement (Wang et al., 2021c). Students are inspired to complete additional tasks as their enjoyment and satisfaction rise due to rewards (Tan et al., 2013). Students compare their scores across activities (Cheng et al., 2009; Ke & Abras, 2013), and were inspired to beat their classmates' scores and make several attempts due to the incentives (Gillispie et al., 2010). In a game-based learning environment, the student played to get a higher score when awarded on an arbitrary scoring basis (Gillispie et al., 2010). A lack of rewards and support reduces students' engagement since they expect higher benefits as recognition of their efforts and achievements (Tzeng & Chen, 2012). Thus, virtual reward holds the potential to mediate the relations between learning satisfaction and engagement, and the associations between learning anxiety and engagement.

Technology Acceptance Model (TAM) aims to explain and anticipate normal behavior. Perceived usefulness (PU) and perceived ease of use (PEU) are two components of the original TAM. Perceived usefulness is the degree to which a person feels that employing a particular system will increase their work performance. At the same time, perceived ease of use is defined as the degree to which a person thinks utilizing a specific system would be effort-free (Davis et al., 1989). The model has been criticized for several shortcomings, one of the common criticisms is the fact that TAM consists of "a decision-making core" that is grounded in basic decision-making processes that seem to be of a universal nature (Bagozzi, 2007). In other words, any 'user motivation' would lead to a 'behavioral intention' leading to 'actual usage'. However, this decision-making core (i.e. 'user motivation') would depend on different causes and effects and should be considered in different contexts. The TAM itself has seen several developments over the years (Lai, 2017).

Earlier studies on online-learning experience have linked it to positive feelings towards an online learning system's ease of use and usefulness (Purnomo & Lee, 2013). Perceived usefulness was a positive factor in predicting engagement in the mobile learning environment (Huang, 2019), and perceived ease of use and perceived usefulness are learning satisfaction indicators (Sun et al., 2008). Mohammadi (2015) discovered that perceived ease of use influences learners' propensity to learn via perceived usefulness and learning behaviors. In early childhood education, perceived usefulness positively influenced online interaction and moderated the relationship between perceived usefulness and overall satisfaction with online resources (Chang & Chen, 2020).

In addition to the above research assumptions based on relevant literature, this study also needs to consider the effects of control variables (Yu et al., 2022). Age (Lai et al., 2020), gender (Wang et al., 2021), and software usage (Wang et al., 2020) may all affect students' behavior, so this study will consider age, gender, years of using a mobile phone and TikTok to be incorporated into the conceptual model as control variables. In summary, this study proposes the conceptual model shown in Fig. 1.

2.4. Research model and hypothesis

This study explored the structural relationships between short-video apps user experience, technological features, and student learning engagement (Fig. 1). Regarding the user experience variables, this study focused on interactions, learning satisfaction, and learning anxiety. In terms of the features, the main focus were product features such as intelligent recommendations, ease of use, playfulness, and virtual reward. As such, we proposed a short video-supported online learning engagement model to examine the complex relations between product/technical factors, user experience, and together how those factors influence student online learning engagement. We attempted to test the following 10 hypotheses by examining our research model (see Table 1).

3. Methods

3.1. Participants and data collection

Given that the questionnaire approach facilitates the generalizability of the findings (Barrett et al., 2021), this study adopted a questionnaire approach to enhance the generalizability of the findings (Pillai et al., 2020). Participants were business and management majors from higher education institutions in an Eastern China city, where teachers started using TikTok videos to deliver their courses during the Fall semester of 2021. First, teachers asked students to share knowledge videos collected from TikTok to increase student engagement, and teachers selected suitable videos to play during offline classes. The video materials were retrieved by students through the latest search engine and sorted according to relevance. Students then discussed the materials to select the most suitable ones, and teachers were also involved in the final selection. These three steps ensured the availability and quality of relevant subject videos. Secondly, teachers taught students to use "PowerPoint" to make learning summary videos, and asked them to share these videos on their TikTok accounts. Moreover, teachers used either pre-recorded videos or Livestream TikTok. Students attended the online course using their mobile devices such as their phone devices or pads. Students like to interact with instructors and peers using bullet chatting or hitting the 'Like/dislike' button. Based on these data, we also ranked the most popular and inspiring short video materials, enriching class formats and increasing learning enjoyment. Virtual reward were ranked according to the number of likes received for the videos created by the students. We awarded a "virtual award" of Moodle points and badges to the 5 most popular videos to encourage active participation. Teachers have used

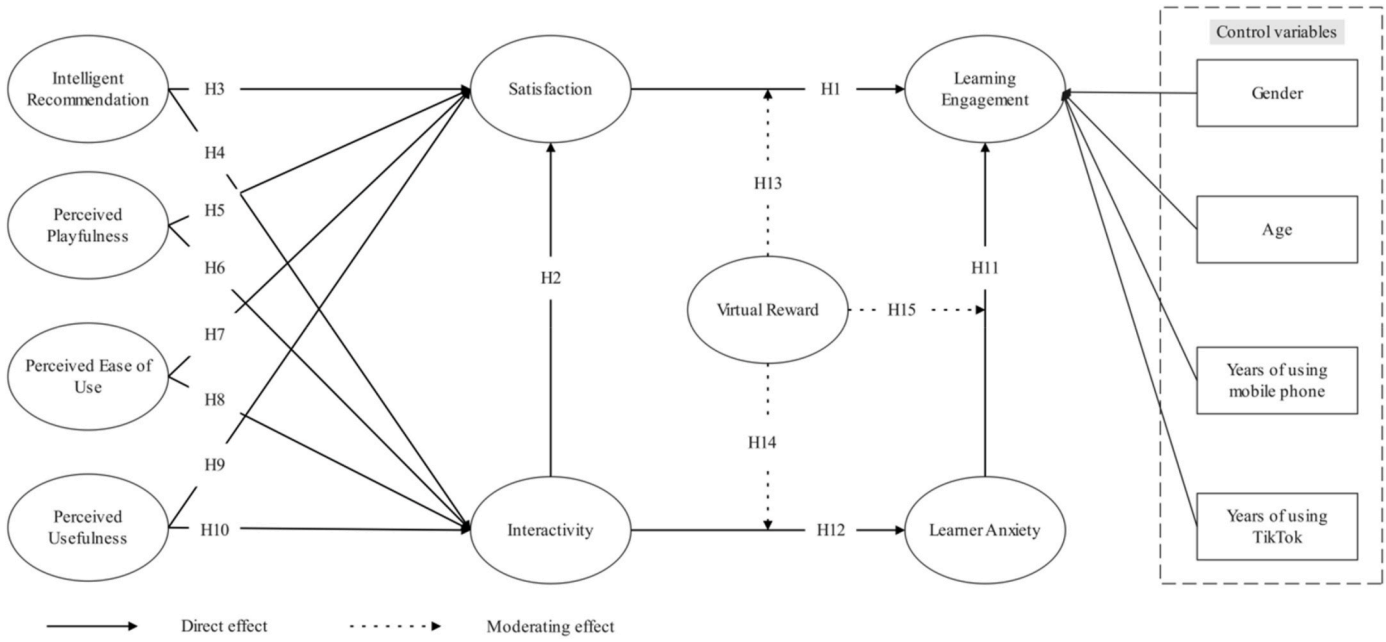

Fig. 1. Conceptual model.

Table 1
Hypothesis.

Hypothesis	Source
H1: Learner satisfaction has a positive effect on learning engagement.	Al-Rahmi et al. (2018), Rajabalee and Santally (2021)
H2: Interactivity has a positive effect on satisfaction.	Liaw et al. (2007), Abdous and Yen (2010)
H3: Intelligent recommendation has a positive effect on learning satisfaction.	Based on H9 and H10
H4: Intelligent recommendation has a positive effect on interactivity.	Carvalho and Macedo (2013), Iglesias et al. (2013)
H5: Perceived playfulness has a positive effect on satisfaction.	Balkaya and Akkucuk (2021), Sarrab et al. (2016)
H6: Perceived playfulness has a positive effect on interactivity.	Arrasvuori et al. (2011), Hsieh and Tseng (2017)
H7: Perceived ease of use has a positive effect on satisfaction.	Purnomo and Lee (2013), Sun et al. (2008)
H8: Perceived ease of use has a positive effect on interactivity.	Purnomo and Lee (2013)
H9: Perceived usefulness has a positive effect on satisfaction	Chang and Chen (2020), Huang (2019)
H10: Perceived usefulness has a positive effect on interactivity.	Mohammadi (2015)
H11: Learner anxiety is negatively linked to learning engagement.	Conrad (2002), Zhang et al. (2020)
H12: Interactivity has a negative effect on anxiety.	Chang and Lin (2019)
H13: Virtual reward positively moderated the relation between satisfaction and learning engagement.	Based on H1 and H2
H14: Virtual reward negatively moderated the relation between interactivity and anxiety.	Based on H12
H15: Virtual reward negatively moderated the relation between anxiety and learning engagement.	Based on H11

TikTok in courses related to e-commerce majors, especially to help students understand obscure noun explanations and summarize what they have learned in class. These initiatives aimed to maximize student engagement using tools they are already engaged with (i.e. TikTok). With the help of faculty members, QR codes for the survey were distributed to students. Students were invited to take part voluntarily. 539 responses were received, and 502 valid samples were obtained through data cleaning, with an effective rate of 93.1%.

All participants (N = 502, 55% female) were undergraduate students. Most of the students (73.9%) were 20–23 years old, and most reported more than two years of mobile phone use experience (70.9%, n = 356). In terms of TikTok use experience, the majority of students have used it for over two years (61.8%, n = 310), 23.3% reported being used for 1–2 years (N = 117), and only 14.9% for less than one year (N = 75).

3.2. Survey instrument

Our research utilized a rigorous process for developing and validating the measurement instrument, strictly following a three-step procedure (Al-Fraihat et al., 2020; Briz-Ponce et al., 2017; Zhang et al., 2019). These adjustments were made to ensure that the survey instrument was more aligned with the actual use of TikTok, thereby improving the study's accuracy (Yawson & Yamoah, 2021). First, all measurement questions were adapted from related scholars' research findings to ensure the scale's quality, which ensured content validity (Cole et al., 2019). Second, we conducted discussion groups with researchers, teachers, and students to optimize and refine the initial version of the questionnaire, ensuring expert validity (Zhang et al., 2019). Third, we tested the scale's reliability through a pre-study with thirty students after completing the initial design. The data passed the reliability and validity tests (Cronbach's Alpha >0.7, KMO>0.7***), proving that the developed measurement tool is suitable for formal investigation (Al-Fraihat et al., 2020). We carefully improved the scale after repeated scrutiny of the responses to the pre-survey (Jiang et al., 2021). The items of Intelligent recommendation were adapted from Pillai et al. (2020); Perceived playfulness was adapted from Tao et al. (2019) and Wang et al. (2021a). In addition, measures of perceived usefulness, perceived ease of use, and interactivity were adapted from Barrett et al. (2021) and Wang et al. (2021c); Moreover, items of virtual reward were adapted from Wang & Huang (2020); Learner anxiety was adapted from Sun et al. (2008); Furthermore, questions on learning engagement adapted from Salmela-Aro and Read (2017) and Teuber et al. (2021). and measurement of satisfaction was adapted from Jiang et al. (2021) and Huang (2021). A 7-point Likert scale was used for measurement in this study (1 for totally disagree and 7 for totally agree) (Zhang et al., 2019).

3.3. Data analysis

This study aims to investigate learning engagement in the context of short video apps which utilize complex research models that involve prediction, moderating variables, and mediating variables, thus partial least squares structural equation modelling (PLS-SEM) is appropriate to conduct the analysis (Wang et al., 2021c; Pillai et al., 2020).

3.4. Common method variance

Since this study collected data using a single questionnaire, it was necessary to check for common method variance (CMV) effects. CMV represents the amount of bogus correlation among the used variables, which may be produced using the same questionnaire to measure each variable (Tehseen et al., 2017). We conducted the CMV test using the multicollinearity test and Harman's one-factor test of variance (Podsakoff et al., 2003; Kock, 2017). The multicollinearity test was performed by examining the Variance Inflation Factor (VIF) results. The analysis showed that the VIF of all items and constructs was less than the threshold value of 3. Using SPSS 25 analysis software, the cumulative share of explanation of the first factor in Total Variance Explained was 29.0% (<40%). The above tests revealed no serious effect of Common method variance in this study (Podsakoff et al., 2003).

4. Results

4.1. Measurement model

The PLS-SEM analysis was divided into two steps: the measurement model and the structural model (Hair et al., 2022; Huang, 2021). The measurement model was tested in content validity, structural reliability, convergent validity, and discriminant validity. The measurement scales were all tested by adapting them from existing research findings and passing pre-tests, so it is reasonable to assume that the measurement model has good content validity (Wang et al., 2021b; Hair et al., 2022). The reliability and convergent validity results of the measurement models are shown in Table 2, and the Cronbach's alpha and composite reliability (CR) for each construct is not less than the critical value of 0.7, indicating that the measurement models have reliable internal consistency (Wang et al., 2021c; Hair et al., 2022). The minimum value of all average variance extracted (AVE) is 0.663 (>0.5), indicating that the measurement model has good convergent validity. The results in Table 3 show that the square root of AVE for all the constructs is greater than the correlation coefficient between that construct and the other constructs. Collectively, the results show that the model has good discriminant validity. The data analysis results show that the SRMR of the model is 0.035 (<0.08), and the RMStheta is 0.098 (<0.12), the above results show that the proposed model has a good degree of fit (Hair et al., 2022).

4.2. Structural model

The structural model of PLS-SEM was examined using SmartPLS 3 with bootstrapping sampling set to 5000 (Hair et al., 2022). The results of the data analysis were obtained as coefficients, R^2, and p-values for each path (see Fig. 2). Among them, perceived ease of use ($\beta_{PEU \rightarrow SA} = 0.055$, $T = 1.385$, $p > 0.05$) and perceived usefulness ($\beta_{PU \rightarrow SA} = 0.035$, $T = 0.895$, $p > 0.05$) did not have a significant effect on satisfaction. Thus, the H5 and H7 hypotheses were not supported. In addition, virtual reward failed to moderate the relationship between learner anxiety and learning engagement, and H14 was not supported. Combined, all hypotheses were supported except for H5, H7, and H14. We also found that gender and age do not affect learning engagement, but the years of using mobile phones and TikTok affected learning engagement.

Table 2
Reliability and convergent validity.

Construct	Item	Loading	Alpha	Composite Reliability (CR)	Average Variance Extracted (AVE)
Interactivity (IN)	IN1	0.838	0.871	0.912	0.721
	IN2	0.848			
	IN3	0.853			
	IN4	0.858			
Intelligent recommendation (IR)	IR1	0.874	0.865	0.917	0.787
	IR2	0.908			
	IR3	0.879			
Learner anxiety (LA)	LA1	0.851	0.883	0.919	0.740
	LA2	0.897			
	LA3	0.848			
	LA4	0.844			
Learning engagement (LE)	LE1	0.816	0.873	0.908	0.663
	LE2	0.780			
	LE3	0.809			
	LE4	0.830			
	LE5	0.835			
Perceived ease of use (PEU)	PEU1	0.863	0.899	0.930	0.768
	PEU2	0.875			
	PEU3	0.903			
	PEU4	0.865			
Perceived playfulness (PP)	PP1	0.846	0.868	0.910	0.716
	PP2	0.841			
	PP3	0.856			
	PP4	0.843			
Perceived usefulness (PU)	PU1	0.859	0.890	0.924	0.752
	PU2	0.901			
	PU3	0.849			
	PU4	0.859			
Satisfaction (SA)	SA1	0.836	0.854	0.901	0.695
	SA2	0.833			
	SA3	0.841			
	SA4	0.825			
Virtual reward (VR)	VR1	0.879	0.891	0.925	0.754
	VR2	0.895			
	VR3	0.846			
	VR4	0.854			

4.3. Analysis of mediating effects

We used the bootstrap approach to analyze the mediating effects (Wang et al., 2021c; Hair et al., 2022). Table 4 shows the t-values of the direct and indirect effects recorded for each mediating effect. In addition, the VAF values for each mediating effect were calculated to determine the mediating effect. As indicated in Table 4, there is no mediating effect of satisfaction on the relationship between intelligent recommendation with learner engagement; there is a partial mediating effect of satisfaction on the relationship between perceived playfulness with learner engagement; there is no mediating effect of satisfaction on the relationships between perceived ease of use and perceived usefulness with learner engagement; a partial mediating effect of satisfaction on the relationship between interactivity with learner engagement; and a partial mediating effect of learner anxiety on the relationship between interactivity with learner engagement.

4.4. Analysis of moderating effects

To explore the moderating effect of virtual reward, we conducted a bootstrap (Wang et al., 2021b; Hair et al., 2022), and the results are shown in Fig. 2. There was a positive moderating effect of virtual reward on the relations between satisfaction and learning engagement ($\beta = 0.244$, $T = 7.622$, $p < 0.001$) and a negative moderating effect of virtual reward on the relation between interactivity and learner anxiety ($\beta = -0.306$, $T = 9.599$, $p < 0.001$). However, virtual reward had no moderating effect on the relationship between learner anxiety and learner engagement ($\beta = 0.034$, $T = 0.994$, $p > 0.05$).

Table 3
Discriminant validity assessment.

Construct	IN	IR	LA	LE	PEU	PP	PU	SA	VR
IN	**0.849**								
IR	0.401	**0.887**							
LA	−0.553	−0.292	**0.860**						
LE	0.468	0.420	−0.527	**0.814**					
PEU	0.525	0.332	−0.398	0.386	**0.876**				
PP	0.339	0.312	−0.281	0.454	0.297	**0.846**			
PU	0.450	0.256	−0.265	0.282	0.292	0.261	**0.867**		
SA	0.580	0.478	−0.365	0.533	0.390	0.340	0.323	**0.834**	
VR	0.176	0.184	−0.197	0.268	0.214	0.247	0.195	0.192	**0.868**

Note: The bolded value is the square root of the construct AVE, and the rest are the correlation coefficients.

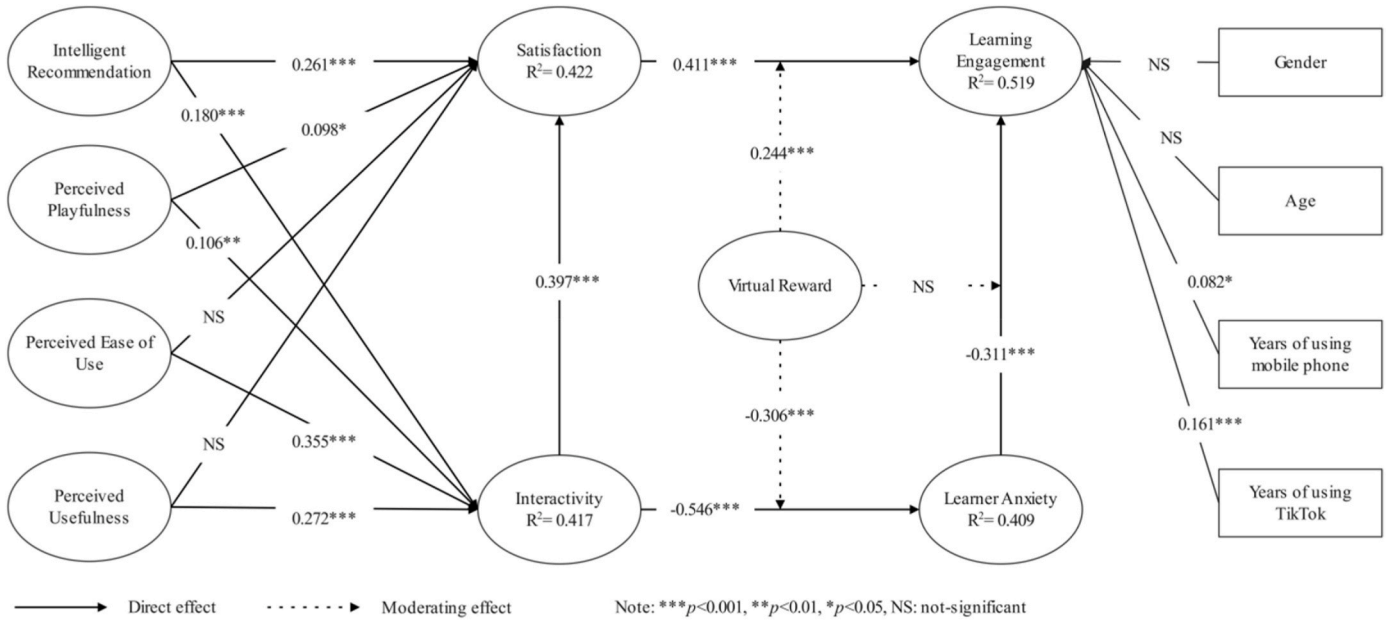

Fig. 2. Research model with coefficients.

Table 4
Mediation testing results.

Effect	Direct effect (*t*-value)	Indirect effect (*t*-value)	Total effect	VAF (%)	Interpretation
IR → SA→ LE	0.090* (2.448)	0.010 NS (1.072)	0.131	7.63%	No mediation
PP → SA→ LE	0.206 *** (5.797)	0.028 * (2.341)	0.073	38.36%	Partial mediation
PEU → SA → LE	0.033 NS (0.879)	0.016 NS (1.356)	0.143	11.19%	No mediation
PU → SA→ LE	0.023 NS (0.653)	0.010 NS (0.879)	0.077	12.99%	No mediation
IN → SA→ LE	0.055 NS (1.124)	0.113 *** (5.308)	0.226	50.00%	Partial mediation
IN → LA → LE	0.055 NS (1.124)	0.112 *** (5.427)	0.226	49.56%	Partial mediation

Note: ***p < 0.01, **p < 0.05, *p < 0.1, ns: not significant.

5. Discussion, implications, and limitations

Short video applications have reshaped instructional environments (Fan et al., 2022). Using TikTok as an example, this study evaluated the potential use of short video apps for maximizing students' learning experience and engagement. The proposed model was supported to a large extent using a PLS-SEM approach. We found that playfulness positively affects satisfaction and interactivity, and interactivity reduces learning anxiety. In this regard, teaching should be enjoyable and engaging. When developing a learning session, it is crucial to make it playful and interesting and to consider enabling AI elements, based on personalized recommendations, as they can potentially boost student engagement (Arrasvuori et al., 2011). Although perceived ease of use and perceived usefulness were not positively associated with satisfaction, both perceived ease of use and perceived usefulness positively impacted interaction, underscoring their importance as indicators of increased student engagement in online learning environments.

This study verified a short video-supported online learning engagement model by introducing new factors, including virtual reward, interactivity, learner anxiety, and intelligent recommendation, in the context of short video-supported learning. Previous study has found that reward-based strategies maximize student engagement and prevent dropout in massive open online courses (MOOCs) (Ortega-Arranz et al., 2019). A further intriguing finding is that virtual reward negatively moderates the relationship between interactivity and learning anxiety. This indicates that the presence of virtual reward contributed to the decrease in both learner anxiety and interactivity. Teachers and course designers should know that learner anxiety is commonly presented in e-learning. Therefore, the useage of AI features such as virtual reality has the potential to reduce students' anxiety. Moreover, a lower level of

anxiety is associated with higher learning satisfaction (Abdous, 2019). Although learner anxiety is frequently seen as having negative implications, the findings demonstrated that more learners assessed anxiety as a facilitative rather than a debilitative influence on engagement (Hilliard et al., 2020). In this study, learner anxiety negatively predicted Learning Engagement (i.e., the higher the learner anxiety, the lower the learner engagement, and vice versa).

Few research has attempted to comprehend the moderating effect of virtual reward on interactivity and learner anxiety relationships. Interestingly, the results refuted our hypothesis 15 (the presence of virtual reward amplifies the negative effect of anxiety on learning engagement). The supported hypothesis 14 indicates that the existence of virtual reward enhances the anxiety level of students. From the perspective of flow theory (Csikszentmihalyi et al., 2014), students experience anxiety when given problems but fewer skills. Thus, when a challenge is too high or a task is too demanding, even if a reward is present, the feelings of anxiousness will not diminish, as the individual may feel they do not deserve it. Teachers are encouraged to employ virtual reward properly in TikTok-based learning since it can increase student engagement and decrease anxiety. To successfully teach online courses, instructors are suggested to constantly monitor students' anxiety, develop short and high-quality course content, integrate plug-ins to enhance interactions, provide rewards such as bonuses and badges, and reduce students' cognitive load and learning anxiety. In addition, instructors can schedule live classes on topics that students may find interesting, employ bullet-screen movies to enhance communication and reduce students' anxiety.

This study has made some theoretical and practical contributions, yet it still has certain limitations. First, while we employed a cross-sectional survey for this investigation, future research could employ longitudinal methods to generate more reliable results. In addition, the analysis of teachers' intentions to use social media and its relationship with student involvement was disregarded since this study focused on understanding how social media influences students' learning engagement. However, this could be an opportunity for future study. Last, in this study, we used a sample only from Chinese undergraduates, readers need to be cautious when interpreting our findings since local, cultural, historical, and geopolitical context is relevant to the adoption, popularity, and engagement with digital technology (Selwyn & Jandrić, 2020). Future studies can use samples from other cultures and countries to understand the use of TikTok in college teaching and how it may promote student engagement.

Furthermore, future research can explore the complicated links between course design and learning engagement in short video-based learning using more relevant theories. For example, studies could analyze the links between basic needs fulfilment and situational learning engagement using self-determination theory (Ryan & Deci, 2000). Alternatively, future research could also investigate the complex mechanism of providing personalized fed content and using bullet-screen videos to promote engagement. Last but not least, readers may also wonder to what extent would TikTok promote students' learning and engagement compared with other social media/tools (e.g., Facebook, Twitter, Instagram)? In other words, comparing the effect of different social media on student engagement may be valuable. These topics were rarely covered in current empirical studies.

6. Conclusion

The pandemic has highlighted the importance of emergency remote learning (ERL) and boosted teenagers' use of short video apps. In this study, we present an educational innovation where TikTok is used as a pedagogical tool, we proposed a model to understand student engagement using short-video-supported applications in the online learning environment. The model includes novel user experience variables (Learning Anxiety & Satisfaction) and technical feature variables (e.g., intelligent recommendation & virtual reward). To the best of our knowledge, this is one of the few studies that present an analysis of the effect of a short-video-supported technology application, namely TikTok, on students' learning engagement. During times of crisis and for a considerable period thereafter, we believe it would shed some light on how social media/tools could play a role in maximizing student engagement.

Ethics approval

Not applicable.

Credit author statement

Conceptualization, S.W.; methodology, S.W.; writing —original draft preparation, S.W., D.Y. and B.S.; writing—review and editing, D.Y. M.L. and B.S.; visualization, D.Y.; project administration, S.W.; funding acquisition, S.W. All authors have read and agreed to the published version of the manuscript.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix

Appendix 1. Survey instrument.

Intelligent recommendation adapted from Pillai et al. (2020)	
IR1	TikTok will recommend short videos that meet my learning needs.
IR2	The short videos provided by TikTok meet my learning needs.
IR3	TikTok allows me to learn what I want to learn.
Perceived playfulness adapted from Tao et al. (2019) and Wang et al. (2021a)	
PP1	Using TikTok to support learning is a joy.
PP2	Using TikTok to support learning is fun.
PP3	Using TikTok to support learning is enjoyable.
PP4	The learning process supported by TikTok is a good experience and not boring.
Perceived usefulness Adapted from Barrett et al. (2021)	
PU1	Learning with TikTok can improve my learning efficiency.
PU2	Learning with TikTok can improve my academic performance.
PU3	Using TikTok for learning can help me accomplish my learning goals.
PU4	Using TikTok for learning is effective.
Perceived ease of use Adapted from Barrett et al. (2021)	
PEU1	Learning to use TikTok is easy for me.
PEU2	Learning through TikTok is easy for me.
PEU3	Learning through TikTok is convenient for me
PEU4	I found TikTok easy to use.
Interactivity adapted from Barrett et al. (2021) and Wang et al. (2021c)	
IN1	When I use TikTok to study, I can interact and communicate with the teacher on time.
IN2	When I use TikTok to study, I can have effective discussions with my classmates.
IN3	When I use TikTok to study, I can express my opinions and comments in the discussion forum.
IN4	When I use TikTok to learn, I can get quick feedback from the teacher on my questions.
Virtual reward adapted from Wang and Huang (2020)	
VR1	Receiving likes and praise promotes my learning.
VR2	Interactive rewards can boost my learning.
VR3	Real-time rewards points can promote my learning.
VR4	A point reward system promotes my learning.
Learner anxiety adapted from Sun et al. (2008)	
LA1	Using TikTok to learn makes me nervous.
LA2	Using TikTok to study makes me feel uncomfortable.
LA3	Using TikTok to study makes me feel uneasy.
LA4	Using TikTok to learn makes me feel confused.
Learning engagement adapted from Tuominen-Soini and Salmela-Aro (2014) and Salmela-Aro and Read (2017); Teuber et al. (2021).	
LE1	When I study, I feel energized.
LE2	I find learning to be full of meaning.
LE3	When I study, time flies.
LE4	I am excited about my learning.
LE5	I feel happy when I pay attention to my studies.
Satisfaction adapted from Jiang et al. (2021) and Huang (2021)	
SA1	I would be happy to use TikTok for learning.
SA2	I think it is a wise choice to use TikTok for learning.
SA3	I am very satisfied with using TikTok for learning.
SA4	I think using TikTok for learning can meet my learning needs.

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