How do ESMA Affect Learning Engagement? An Empirical Study Based on SOR Theory

Jigang Ma[1] Ping Wang[2] (corresponding author)

1 Kaifeng Vocational College, Kaifeng, 475100;

2 School of Economics and Management Zhengzhou Technology and Business University, Zhengzhou, 451400;

Abstract: Objectives: This study explores the relationship between social media usage and learning engagement and the mechanisms behind it

Methods: A questionnaire survey was conducted among 727 university students. Statistical equation modeling (SEM) was used to analyze the data and test the hypotheses based on the SOR model.

Results: The results revealed that ESMA had a direct impact on both learning engagement and sleep disturbance among university students. However, the relationship between ESMA and these outcomes was mediated by immersive experiences. Furthermore, sleep disturbance did not directly affect learning engagement, and ESMA influenced learning engagement through sleep disturbance. This study explores the relationship between social media usage and academic engagement and the mechanisms behind it.

Conclusions: The study provides empirical evidence for how new media affects learning and sleep among university students. Educators and administrators should consider guiding students in the appropriate use of social media, such as short videos, to minimize negative impacts on their learning and sleep.

Keywords: ESMA; Sleep disturbance; Immersive experience; Learning Engagement; SOR theory

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1 Introduction

In the 21st century, an era characterized by informatization and networking, mobile devices such as smartphones and tablets have deeply penetrated people's daily lives and become an indispensable part of them[1, 2]. The outbreak of the COVID-19 pandemic has further accelerated this trend. Innovative teaching and working from home have made the Internet the primary avenue for accessing learning information and work resources[3]. Simultaneously, social media and online platforms, including short-form videos, have emerged as new frontiers for knowledge sharing and learning[4, 5]. However, it is worth noting that people's reliance on digital platforms for socializing, entertainment, and information sharing during the pandemic may have altered their digital lifestyles[6]. This phenomenon is particularly evident among university students. As a young, active, and inherently curious demographic, they are more familiar with and dependent on these smart devices and social media. With the explosion of Chinese video apps like TikTok and Kwai, short video applications have taken over universities across China. However, such software makes it easy for students to become immersed in them[7]. Statistics show that the consumption of short videos is constantly growing.

Nevertheless, the reliance of university students on short-video social media has also raised concerns. The immersive nature of these platforms often leads students to neglect crucial aspects of their daily lives, such as studying and sleeping[8][9]. Balancing regular studying and living while avoiding excessive Immersive in social media, like short videos, has become a significant challenge for contemporary university students.

It must be acknowledged that the COVID-19 pandemic has accelerated the proliferation of digital lifestyles. Specifically, the portability of mobile devices has significantly facilitated university students' use of social media, leading them to spend increasingly more time on it[10] Excessive social media use has seriously affected university students' studying and overall well-being [11]. This behavioral change is not without consequences, as pandemic-induced behavioral issues such as social media addiction and neglect of real-life socialization may have adverse effects on some individuals' psychological and behavioral health[8]. Simultaneously, psychological, and behavioral health issues and digital lifestyles may emerge as a widespread public health concern[6]. The research questions this study aims to explore is whether excessive use of short-video social media applications can impact university students' studying and sleep in the current context of widespread mobile social media use. If so, how does this impact manifest?

When addressing psychological and behavioral issues, the SOR model is a commonly used theoretical framework. This framework helps explain the usage behavior of internet tools/systems. If we view university students' social media usage as a SOR process, the portability and functionality of mobile devices and social media serve as stimuli (S), leading to physiological and psychological states (O) that influence usage behavior. At the same time, excessive use may result in studying and lifestyle issues, as well as adverse effects on psychological and behavioral health (R).

The process also provides a theoretical framework for understanding and intervening in this issue. By utilizing the theoretical framework of the SOR model, this study aims to shed light on the psychological and behavioral health issues among university students in their digital lifestyles. It reveals the complex relationship between digital lifestyles and university students' psychological and behavioral health, hoping to provide a scientific basis for developing relevant intervention strategies.

2 Literature review

2.1 Theoretical foundation

The theoretical foundation of this study is anchored in the Stimulus-Organism-Response (S-O-R) model, which builds upon the foundational stimulus-response theories of Woodworth (1929) and Pavlov (1927) [12, 13]. The S-O-R framework comprises three integral components: the stimulus, the organism, and the response. This model posits that an individual's psychological state is influenced by environmental stimuli, as evidenced by the work of Jacoby (2002) and Peng and Kim (2014)[14, 15]. Specifically, the content and format of short videos, along with the interactive processes and outcomes (e.g., likes, comments, and purchases), can affect a user's psychological state and subsequent reactions.

At its core, the S-O-R model delineates the internal systems and processes that assimilate external stimuli, converting them into reactions, actions, or responses by the individual[16]. Perceptual, physiological, emotional, and cognitive processes mediate this stimulus-response dynamic. In this research, the Event-State Model of Affect (ESMA) was employed to assess students' emotional responses, indicative of their internal psychological and emotional states.

The response in the S-O-R model is defined as the outcome of an individual's attitude and behavioral intentions, which can be either positive or negative [17, 18]. These responses manifest as either approach or avoidance behaviors, exemplified by positive actions like learning and purchasing intentions or negative behaviors such as avoidance. The study highlights that excessive social media usage may negatively impact sleep and learning motivation[19]. The S-O-R model has been extensively utilized by researchers to examine behaviors in contexts such as business relationships, mobile auctions, and social media engagement[20, 21].

2.2 Related studies and hypotheses

2.2.1 The relationship between excessive short-form video social media applications (EMSA) and immersive experience

The concept of Immersive, originating from explorations in virtual reality technology, has gained widespread recognition in video gaming[22]. Players are fully absorbed in a game and exhibit indifference to time and the natural world, which exemplifies the immersive experience (Brown & Cairns, 2004; Jennett et al.). Similar immersive experiences have become increasingly prevalent among university students with the rise of short-form social media videos. With their unique content format and visual appeal, short videos readily induce an immersive state among viewers. University students tend to watch these videos intensely, losing track of time and becoming oblivious to changes in their surroundings, mirroring the immersive state of virtual gaming[23]. However, unlike virtual games, short videos have a lower barrier to entry and are more accessible, thus facilitating their overuse.

Based on these observations, the hypothesis is proposed:

Hypothesis1: EMSA enhances the immersive experience.

2.2.2 The relationship between immersive experiences and sleep disturbance

Immersive experiences are frequent when engaging in various online activities. Psycho-physiological experiments have shown that when individuals engage in video games, Immersive experiences are accompanied by increased dopamine levels in the body. Increased dopamine agonists, similar to some of the characteristics of Immersive experiences, are accompanied by increased attention and a sense of complete control over an activity, while neglecting their basic needs[24]. Furthermore, experimental psychology experiments have shown that a moderate level of arousal characterizes Immersive experience, as reflected through sympathetic inhibits sleep [19, 25]. Therefore, the Immersive experience due to the use of short videos affects normal sleep and positively impacts sleep disturbance, and the following hypothesis is proposed.

Hypothesis2: Immersive experience could exacerbate sleep disturbances.

2.2.3 The relationship between immersive experience from short videos and learning engagement.

The literature on learning engagement and Immersive experiences needs to be improved. Existing studies prove that Immersive experiences can positively influence game-based learning outcomes. For example, it has been found that although Immersive experiences are beneficial, they do not significantly correlate with learning outcomes. In contrast, the enjoyment derived from educational games is positively correlated with immersive experience [25]. Structural equation modeling further highlights the interconnectedness between perceived learning and immersive experiences. Nonetheless, the link between Immersive experiences and learning engagement needs to be stronger and requires more rigorous investigation Immersive[26]. Although these findings provide tentative support for a positive association between Immersive experiences and game-based learning engagement, generalizing these results to broader domains necessitates additional empirical inquiry. It is worth noting that the present study's focus on ESMA, which primarily emphasizes entertainment and relaxation, needs to align with learning engagement seamlessly. Hence, drawing upon the deliberations above, we posit the following hypothesis:

Hypothesis3: Immersive experience from short videos is negatively associated with learning engagement.

2.2.4 The relationship between ESMA and sleep disturbance

Short-form social media applications, with their concise and engaging content, have captivated a vast audience, particularly youth. These platforms are often characterized by high interactivity and immediacy, leading to easy Immersive and potential overuse by users. Prolonged exposure to screens, especially before bedtime, can inhibit the production of melatonin, a crucial hormone that facilitates sleep. Moreover, the stimulating content and constantly refreshing information feed within these applications can keep users' brains in a state of arousal, further disrupting sleep. [27].

University students' use of social media enhances their receptivity to educational opportunities and novel experiences. However, it often results in poorer self-control, making them more susceptible to excessive use of short-form social media when away from parental supervision. Excessive use of short-form social media refers to an individual's undue focus and disproportionate allocation of time and energy, which can ultimately impair their physical, psychological, and social functioning. Research indicates that this excessive use can lead to significant sleep disturbances, characterized by deteriorating sleep quality and reduced duration [28]. Using short-form social media before bedtime is also

typical among university students. According to the Sleep Disturbance Theory, cognitive arousal occurs when the mind is active before bedtime and involves thinking, worrying, planning, and problem-solving. This state of arousal makes it challenging for individuals to control their thoughts, leading to sleep disturbance. Based on the studies above, the hypothesis proposed in this research is as follows:

Hypothesis 4: ESMA significantly escalates sleep disturbance.

2.2.5 The relationship between ESMA and learning engagement.

Learning engagement refers to a student's participation in educational activities in order to more effectively acquire knowledge and skills [29], and Learning environments influence it. Short-form social media applications, with their brief, entertaining, and easily digestible content, have attracted a significant user base, especially among student populations. These platforms often provide highly personalized and interactive experiences, resulting in student Immersive and academic distractions. Excessive use of these applications consumes time and energy that could otherwise be allocated to study, thereby diminishing students' academic engagement[30].

Learning engagement refers to the positive attitude, concentration, and effort students exhibit during the learning process. It is a critical factor in assessing student learning outcomes and academic achievements. However, the overuse of short-form social media applications can undermine students' motivation to learn, decrease their interest and concentration, and subsequently impact their academic engagement. However, when university students are keen to use their smartphones for social networking, instant messaging, online gaming, and entertainment, they can be distracted from their studies. If used irresponsibly, it may create a lack of engagement in learning for university students. Researchers have found that addictive behaviors are considered to be a cause of under-engagement in learning among university students and lead to burnout [31]. However, learning engagement and learning burnout, as two sides of the same coin, are two extremes of an individual's learning status [32]. Therefore, Internet addiction affects learning engagement to some extent.

Higher levels of personal learning burnout are typically interpreted as lower levels of engagement in learning, as well as the reverse. Additionally, the study supports the relationship between internet addiction and a desire to study. Based on above research, short-form video social media is a software application which is used in an online setting on a portable device such as a mobile phone. Thus, addiction to short videos on a mobile phone or tablet over also gives rise to the following Hypothesis.

Hypothesis 5: ESMA negatively predicts learning engagement.

2.2.6 The relationship between sleep disturbance and learning engagement.

Based on previous hypotheses and existing researches, ESMA has been found to deteriorate sleep quality and reduce sleep duration, ultimately leading to sleep disturbance [33, 34]. Sleep plays a crucial role in maintaining physical and mental health, as well as facilitating the learning process. Adequate sleep contributes to relaxing the body and mind, repairing the brain, and restoring energy[33]. For students, both the quality and quantity of sleep are closely associated with their learning capabilities and academic performance. Sleep deprivation can diminish students' attention, concentration, and memory, which are key factors in learning engagement. Studies have demonstrated that sleep deprivation significantly impacts students' learning engagement and academic outcomes [35].

Therefore, the following hypothesis are proposed:

Hypothesis 6: Sleep disturbance negatively associates with Learning engagement.

Hypothesis 7: Sleep disturbance mediates the relationship between ESMA and learning engagement.

2.2.7 Research on the mediation between ESMA, Immersive experiences, sleep disturbance and learning engagement.

Based on previous hypotheses, there may be a close relationship between ESMA, immersive experiences, sleep disturbance, and learning engagement. These mechanisms are likely to be interconnected and interact with each other in some way. In real-life situations, individual factors rarely influence a person's behavior or mental state in isolation. Therefore, mediation analysis can provide a better understanding of these multifaceted interactions. The present study aims to explore the relationships between ESMA, immersive experiences, sleep disturbance, and learning engagement among Chinese university students. Using the Stimulus-Organism-Response (S-O-R) theory as a framework, where short-video social media usage serves as the stimulus, students' immersive experiences represent the internal state of the organism, essentially an intrinsic motivation [36], and learning and sleep are considered as responses. Combining this theoretical framework with hypotheses H1-H7, we propose the following mediation hypotheses.

Hypothesis8: Immersive experience mediates the relationship between ESMA and learning engagement.

Taking the above assumptions into account, we conceptualize the following model (seeing Figure 1)

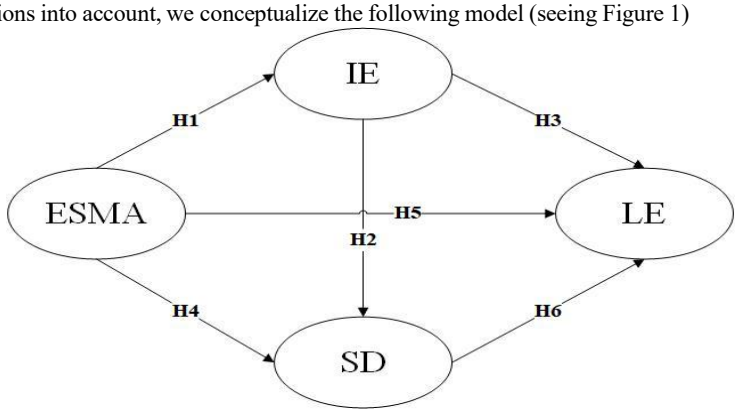

Figure 1 Research hypothesis

3 Materials and methods

3.1 Data collection

The 2024 Henan Educational Report indicates that there are 3,096,500 university students in Henan Province. Based on the Morgan scale, a sample size of 384 university students from Henan is required for the survey. After obtaining approval from the local psychology ethics committee, participants were recruited online through the Henan University Students' website from May to June 2024. All participants were informed about the study and provided with informed consent.The inclusion criteria were that a university student with sufficient proficiency in Chinese or comprehension skills would complete all related questionnaires and online data collection. Participants were asked to provide basic demographic details in the questionnaire, which took approximately 10 minutes to complete. Eight hundred-seven university students participated in the study, with 727 providing valid data, resulting in a validity rate of 90.33%.

Based on previous research, this study's core model uses a construct previously used in the field. In developing the items in the questionnaire, literature and pre-validation scales were consulted. It was validated by a panel of statistical experts, who confirmed that the content of the questionnaire was accurate. The IP address of the intelligent communication device was used in this study to screen duplicate samples to improve the questionnaire's quality. The unusable questionnaires were removed if they were too short or had lots of duplicate values. In this study, there was a large sample size, in addition to the above measures, greatly enhanced the statistical power and robustness.

This study was conducted on the demographic information of the university students who participated in the study, and the primary information included was Gender, Academic subjects, Spending watching short videos, Types of short videos, Grade, identity, and Household income monthly. Specific information for each item is shown in Table 1.

3.2 Research instruments

According to the study, the respondents were given a Likert scale of 1 to 7 (strongly disagree = 1 and strongly agree = 7).

Short-video media dependence scale the social networking site dependence scale developed by Milošević-Đorđević' and Žeželj (2014) was used, and the original scale has been modified to meet the needs of this study by replacing the term "social networking sites" with "short-video social networking sites" in each title.

It might be broken up into subsections. The paper should clearly and concisely explain the experimental findings, their interpretation, and any possible conclusions drawn from the experiments. Excessive use of short-form video social media applications was measured with six items. Example items included: “Since I have been on short-form video social media, my performance at learning is worse”. Due to the amount of time, I spend watching short-form videos, I do not sleep well as a result of ESMA." A higher score means more serious symptoms. An average of the 6 items was calculated (M = 3.48, SD = 1.38, and Cronbach's alpha = 0.893). Yu and colleagues developed the Sleep Disorders Scale to measure sleep disturbance [37]. The scale consists of five items; Example items included: “Poor sleep made me have trouble concentrating”, “I was sleepy, so I had problems getting things done." Higher scores indicate poorer sleep quality. The 5 items were averaged (M = 3.77, SD = 1.58, Cronbach’s α = 0.951).

Table 1 Demographic

Measure	Item	Frequency	Percentage (%)
Gender	Male	409	56.30
	Female	318	47.30
Academic Subjects	literature and history	204	28.10
	Science and Engineering	523	71.90
Spending Watching Short Videos	＜1 hour	163	22.00
	1-4 hour	510	70.00
	＞5 hour	54	8.00
Types of Short Videos	TikTok	479	65.90
	Quick Hands	114	15.70
	Bili Bili	93	12.80
	Other	41	5.60
Grade	Freshman year	256	35.21
	Sophomore	237	32.61
	Junior	150	20.63
	Senior	84	11.55
Identity	The creator	4	0.50
	The viewer	561	77.20
	Both	162	22.30
Household income monthly	Less than 3000RMB	196	27.00
	6,000-9,999RMB	313	43.10
	10,000-14,999RMB	136	18.70
	More than 15,000RMB	36	0.50
	Total	727	100.00

Immersive experience Scale[37] which we assessed using four items. A few examples include: "I sometimes lose track of time when I am using SMA." Among the examples: It is impossible for me to keep track of time when I use SMA," " As soon as I start using SMA, I'm absorbed in it”, and "I really enjoy using SMA." Based on the four items, an average was calculated (M = 3.77, SD = 1.42, Cronbach’s α = 0.869).

The Learning Engagement Scale[38], A total of four items were assessed. Examples include: "After Using SMA, I'm willing to take

effective learning." "After Using SMA, I'm willing to resolve practical learning problems."

4 Result

The analysis and estimation were performed in two phases using partial least squares (PLS). In the first phase, reliability and validity analyses were conducted, followed by an estimation phase, However, the second phase assessed Structural models are powerful explanations and estimated its path coefficients. By confirming the constructs' reliability and validity, the two phases above confirmed their relationships [39]. Considering that it considers construct variables and measurement items simultaneously and allows for causal relationships to be discussed. Additionally, it facilitates discussions of causal relationships between construct variables and allows simultaneous modeling of measurements and constructs [40]. Compared to other methods of SEM analysis, PLS was more suitable for the research.

4.1 Outer model and scale validation

Several tests were conducted on each construct within the outer model, including tests for reliability, convergent validity, and discriminant validity. Question loadings tested the items' reliability. Factor loadings presented some questions' ability to measure the extent of the construction, as a result, all the measurement items met the standards after the fourth question in the playfulness construct was deleted. The threshold value was 0.6, which represents individual reliability. As can be seen in Table 2, each construct had composite reliability (CR) values greater than the threshold value of 0.75[41], which indicated the constructs' internal consistency.

Table 2 Outer model reliability and Average Variance Extracted (AVE)

Construct	Cronbach's alpha	Composite reliability	AVE
IE	0.872	0.869	0.624
LE	0.916	0.919	0.734
SD	0.951	0.951	0.797
ESMA	0.893	0.893	0.625

Note: IE=immersive experience; LE=learning Engagement; SD=sleep disturbance

ESMA= excessive use of short-form video social media application

The AVE metrics for each construct are considered the AVE metrics for each construct, taking into account convergent validity, using factor loadings for measurement can lead to issues regarding reliability and convergent validity [42]. Based on Table 2, the AVEs for potential variables ranged between 0.624 and 0.951, indicating a high degree of convergent validity.

The discriminant validity of a construct is based on its ability to discriminate between the variables being tested and the construct's guidelines. As Henseler et al. (2015) pointed out, the Heterotrait-Monotrait (HTMT) Ratio of Correlations is a technique for testing method validity. Therefore, HTMT was used in this study to evaluate discriminant validity. It was determined that HTMT helped evaluate discriminant validity, as identified by Henseler and Sarstedt [43]. All values, as shown in Table 3, are below 0.90; in addition, Table 3 shows a reasonable relationship between cross-loading and using factor loading; each indicator was found to have discriminant validity. Factor loadings are higher for scale items associated with their assigned latent constructs[44]. A scale item's factor loading will be more significant if the scale item is associated with its latent constructs.

Table 3 HTMT

Factors	IE	LE	SD	ESMA
IE	0.790			
LE	0.173	0.856		
SD	0.693	0.089	0.892	
ESMA	0.726	-0.015	0.672	0.790

Note: IE=immersive experience; LE=learning engagement; SD=sleep disturbance

ESMA=excessive use of short-form video social media application

4.2 Testing hypotheses and inner models

To testing the hypotheses, this study used an inner model PLS analysis. Once the inner model path coefficients and R-square were estimated, we performed the PLS analysis. With path coefficients, we can determine how latent variables influence observed variables. It indicates how well the model can predict, as opposed to R-squared, which indicates how much variance the model can explain. A resample of the data was also conducted to enhance the accuracy of the estimation of each path coefficient in addition to bootstrapping. Consequently, the estimated values were more precise than the commonly accepted value for the limit [45]. The results of the relationships between the variables and the mediating effects are shown in Table 4.

Table 4 Inner model and Intermediary effect

Hypothesis	Path coefficient	T-Value	Result
H1: ESMA →IE	0.726***	22.306	Supported
H2: IE → SD	0.434***	6.516	Supported
H3: IE→ LE	-0.370***	4.89	Supported
H4: ESMA → SD	0.357***	5.288	Supported
H5: ESMA → LE	-0.312***	4.22	Supported

H6: SD → LE	0.042	0.651	Not Supported
H7: ESMA → SD → LE	0.019	0.949	Not Supported
H8: ESMA → IE → LE	0.165***	4.704	Supported

Note1: IE=Immersive experience; LE=learning engagement; SD=sleep disturbance; ESMA=excessive use of short-form video social media application

Note 2: * p-value < 0.05; ** p-value < 0.01; *** p-value < 0.001.

Note 3: Number of bootstrap samples = 5000

ESMA had a favorable and significant impact on immersive experience, which positively affected sleep disturbance and learning engagement, supporting hypotheses 1, 2, and 3(ESMA → IE: β = = 0.726, t = 22.306; IE → SD: β = 0.434, t-value = 6.516; IE → LE: β = -0.370, t= 4.890). As a result, H6 was supported (ESMA → IE→ LE: β = 0.165, t-value =4.704).

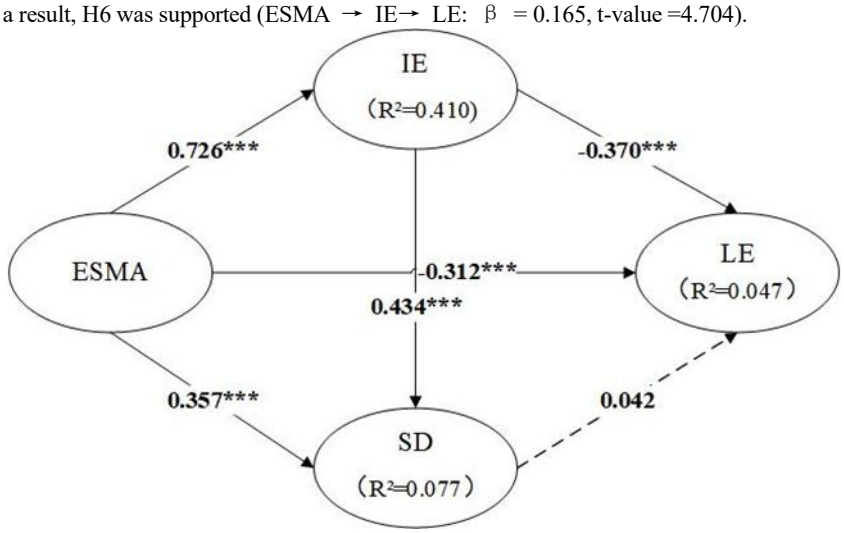

Figure 2 Inner model standardization coefficients and significance

Note: IE=Immersive experience; LE=learning engagement; SD=sleep disturbance; ESMA=excessive use of short-form video social media application

ESMA had a favorable link with sleep disturbance but a negative relationship with learning engagement, which supported hypotheses 4 and 5(ESMA →SD: = 0.357, t-value = 5.288; ESMA→ LE: = -0.312, t-value = 4.22). However, sleep disturbance did not affect learning engagement, and H6 was not supported (SD → LE: β = 0.042, t-value = 0.651). As a result, H7 was not supported (ESMA→SD → LE: β = 0.019, t-value = 0.949). Inner model standardization coefficients and significance are shown in figure 2.

5 Discussion

The use of smartphones among the mass population in China and the widespread popularity of short-form social media apps have made university students vulnerable social media short-forms and their effects. The research uses an S-O-R perspective to investigate how ESMA affects learning engagement. To clarify potential processes, Immersive experiences and sleep disturbance were included in this association. The results of this research show the connection between stimuli (such as stress), organisms (such as Immersive experiences), and reactions (i.e., sleep and learning). The results of this study provide insight into ESMA's status among university students and have practical implications for prevention strategies and intervention of ESMA by examining the impact of ESMA on sleep and learning.

5.1 Theoretical implications

First, according to the model of S-O-R, EMSA predicts sleep disturbance. The Immersive experience acted as a mediating variable to mediate this process, and Hypothesis1, 4, 5 and 8 were confirmed. Research findings from the past are consistent with this one. In the study, there is evidence to support the hypothesis of sleep process interference theory. Students who constantly watch short-form videos on social media may become engrossed in short-form videos, constantly thinking about what they have watched and what they plan to post, causing cognitive arousal that interferes with their sleep, thus leading to sleep disturbance. From another perspective, since short-form social media use and sleep are two incompatible activities, the two are not aligned in direction and inevitably have disruptive outcomes.

Second, according to the literature, it could be detrimental to your health to spend a lot of time online, such as difficulties and addictive behaviors. A negative association between ESMA and learning engagement was found in our study, and hypothesis 2 is both compatible with our hypothesis and supported by the literature. When university students are keen to use their smartphones for social networking and entertainment activities, they become distracted from their studies. If not managed, this may bring about a lack of engagement in learning [31]. Based on S-O-R theory, Immersive experiences can mediate the relationship between ESMA and sleep disturbance and learning engagement, hypothesis4, hypothesis 6, and hypothesis 7 hold.

Thirdly, hypotheses H6 and H7 was not supported. It indicates that although ESMA can directly negatively affect learning engagement, it does not mediate learning engagement through sleep disturbance. Even though they used ESMA, university students are less affected by it

because they are younger and more resilient to stress. It may be the possible reason. Another reason for the lower impact on university students' study engagement is that they have more independent time and are less stressed about their studies than high school students.

Another possibility is that numerous factors influence engagement in learning. In addition to the general factor of sleep, other more critical influences may have been overlooked in this study, and these potential influences need to be explored further in the future[46]. How ESMA affects university students' learning engagement may have other pathways tested through new empirical research. It indicates that although ESMA can directly negatively affect learning engagement, it does not mediate learning engagement through sleep disturbance.

5.2 Practical implications

Firstly, universities should strengthen the planning and guidance provided to university students regarding their leisure time. By offering various extracurricular activities, academic research opportunities, and encouragement to participate in social practices, they can guide students to utilize their free time effectively for personal growth and broadening their horizons[23]. Simultaneously, directing students toward developing healthy smartphone usage habits is crucial. Furthermore, mechanisms for limiting smartphone usage time, such as setting reminders or restricting the usage of specific applications, should be established to mitigate the negative impacts of excessive reliance on mobile phones on their academic and personal lives[24].

Secondly, this study advocates for a collective effort between families, educational institutions, and society to address smartphone dependency among university students effectively. Families should reinforce educational guidance for their children, fostering a balanced and responsible approach to smartphone usage[26]. Meanwhile, society ought to cultivate a favorable environment conducive to responsible smartphone usage, complemented by strengthened regulations and norms governing mobile phone usage patterns[30].

The practical implications proposed by this study lie in adopting targeted management strategies and collaborative multi-stakeholder. It approaches to effectively mitigate smartphone dependency among university students, subsequently improving sleep quality and academic engagement. It enhances students' physical and mental well-being and academic performance and is a valuable reference for future research endeavors aiming to intervene in smartphone dependency issues[35]. Simultaneously, this study calls for increased attention from scholars and researchers toward the pertinent issue of smartphone dependency, collectively contributing to the healthy growth and development of the university students.

5.3 Limitations of current research and future directions

Our study has five limitations. First, we collected data from Chinese students at Chinese universities. A number of countries have adopted a short form due to the popularity of social media [47], data based on one country is limited in its ability to understand this global phenomenon. As a result, future research may compare how short-form video social media is used in other countries. The second reason for our inability to demonstrate causality is that Cross-sectional data were collected in the survey. Therefore, we recommend adding longitudinal data collection to the model to test causal effects. Thirdly, the current study's conflicting direct and indirect pathways between short-form social media use and learning engagement suggest that other mechanisms of action exist that we have not yet addressed. Future research could go further. In addition, self-reported assessments of learning engagement and ESMA use are susceptible to social desirability biases and estimation errors [48]. Developing reliable and valid measures of SMA on smartphones might be possible in the future. Finally, the study population consisted exclusively of university students, with a small number of participants. For further research on the effects of social media use, stratified sampling could be used to recruit a larger group of people from different ages on consumption, employment, and education, and life of different groups.

6 Conclusions

Chinese university students were evaluated for their learning and sleeping behaviors relative to ESMA. The flow of experience mediates the relationship between ESMA, learning, and sleep disturbance. As a result of our findings, the existing knowledge is enhanced in many ways.

Here is the purpose of this study was to investigate the pathways through which ESMA affected sleep disturbances and learning engagement in accordance with the SOR theory. Experiencing Immersive directly affect student learning engagement and sleep disturbances. The effect of sleep disruption on learning engagement, however, was not observed. In addition, our study examines the mechanisms by which flow experiences interrupt sleep and influence learning engagement, according to the mind-flow theory.

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Conflicts of interests

Competing interests have not been disclosed by the authors.

Data Availability Statement

There is a section of the article in which the data supporting the findings of this study can be found.

Ethics Approval and Informed Consent

This is to certify that the research project identified below has received an approval on human research protection by the Human Research Ethics Committee, Stamford International University, which is in full compliance with international guidelines of human research protection of the Belmont Report (Code: STIU-HREC023/2023).

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Corresponding author:wangping812103@163.com