Effect of e-learning environmental stimuli on learning engagement in the context of COVID-19

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Abstract

The COVID-19 pandemic at the beginning of 2020 has changed the conventional learning mode for most students at schools all over the world, and the e-learning at home has become a new trend. Taking Chinese college students as the research subject and drawing on the stimulus-organism-response (S-O-R) model, this paper examines the relationship between the peer referent, perceived closeness and perceived control and the learning engagement. Using data from 377 college students who have used the e-learning, this study shows that perceived closeness, perceived control and peer referents in e-learning have a positive effect on the self-efficacy and well-being of students, thus improving students' enthusiasm for learning. Our intent is to assist researchers, instructors, designers and others in identifying effective methods to conceptualize and measure student engagement in e-learning.

Keywords: COVID-19, e-learning, environmental stimuli, learning involvement, SOR model

Introduction

Learning environmental stimuli have always been the key factor affecting the level learning intention among students (Chang, Chen, Lin, & Sung, 2008). Many studies have shown that good learning environmental stimuli enhance students' intrinsic learning motivation and helps them to obtain the required knowledge and skills, thus achieving the scheduled goals (Bojuwoye, Moletsane, Stofile, Moolla, & Sylvester, 2014). Mashau (2000) holds that schools have the responsibility for creating a favourable learning environment to promote effective learning, and students would benefit from mutual assistance among peers, improved courses and high-quality teaching strategies in such an environment (Hewson & Hewson, 1983). Nowadays, college education is facing multiple challenges, and encouraging student engagement in learning has become the focus of increasing attention (Ngidi & Qwabe, 2006).

Allen and Seaman (2011) point out that about one third of students pursuing higher education in

America have attended one or more e-learning subject at home. Bach, Haynes, and Smith (2006) regard e-learning as a critical component for the popularization of higher education. In particular, since the onset of the COVID-19 global pandemic in January 2020, countries all over the world have suspended (to a certain extent) economic, tourism and catering activities, especially educational activities. China, which suffered early from the epidemic, schools carried out remote teaching through e-learning to allow students to learn at home, and e-learning changes traditional educational activities to a digital form in terms of content and systems (Putra, Ridwan, Mulyani, Ekajaya, & Putra, 2019). However, students' engagement in e-learning is obviously lower than in face-to-face teaching (Dietz-Uhler, Fisher, & Han, 2007). Jonassen, Howland, Moore, and Marra (2003) propose that one possible reason may be that the student attention in e-learning is easily distracted by other factors. The change of learning environment may also lead students to drop out of school or reduce their enthusiasm for pursuing their degree courses (Jaggars, 2014).

Although students can acquire valuable knowledge and information from teachers via e-learning, it is not certain that such knowledge and information can be converted into high quality competence. In studies of organizational management, Zaheer and Bell (2005) found that more attention should be paid to the internal

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capability of an organization in knowledge absorption (i.e. the learning engagement), while the acquisition of external knowledge and information tends to be more often discussed (Cohen & Levinthal, 1990). In terms of the connectedness stressed by Fabrizio (2009), students should be able to engage in learning

actively, and transmit and use knowledge. Although teachers have provided abundant and valuable information in the context of e-learning, learning quality is particularly difficult to control (Putra et al., 2019) and higher learning engagement from students is required. Most previous studies have discussed the importance of e-learning (Wang & Wang, 2011), but there have been few studies on the impact of the learning environmental stimuli perceived by students in e-learning on student engagement. Here, we introduce the stimulus-organism-response (S-O-R) model and connect learning engagement in e-learning with the e-learning environment. Although previous studies have used this framework to examine the effect of the e-learning human-computer interface (HMI) on student behaviour (Zhang, Lu, Gupta, & Zhao, 2014; Zhang, Lu, Wang, & Wu, 2015), this study emphasizes the environmental factors of e-learning, rather than the technical factors, demonstrating the applicability of using the S-O-R model when considering learning engagement in the context of e-learning. In particular, this study focuses on the current situation of learning engagement among college students in the context of e-learning due to the COVID-19 pandemic.

Literature review and theory development

The S-O-R model involves three components: stimulus, impact and response. It assumes that stimuli (S) are included in the external environment and cause changes to people's internal organisms (O), which in turn affect their behavioural responses (R; Mehrabian & Russell, 1974). This model is used to conceptualize the individuals' responses to environmental information. It can capture behavioural responses and elements in complex decision-making processes (Bagozzi, 1983). In this theoretical framework, stimuli appear in different forms, including environmental factors and interpersonal relationship (Animesh, Pinsonneault, Yang, & Oh, 2011; Liu, Guo, Ye, & Liang, 2016). Such changes to internal status appear in the perception of stimuli and behaviours, including affective, cognitive, perceptual and mental activities. Previous studies of the S-O-R model have considered a wide range of stimuli, including social support (Zhang et al., 2014), flow

(Animesh et al., 2011; Gao & Bai, 2014; Zhang et al., 2014), feeling (Kim & Johnson, 2016; Koo & Ju, 2010; Vieira, 2013) and interaction (Animesh et al., 2011; Mollen & Wilson, 2010; Zhao & Lu, 2012). The individual response after the reception of stimuli refers to the effective attitude and intention in subsequent individual behaviours, such as learning autonomy and learning intention (Animesh et al., 2011; Ha & Im, 2012).

According to the S-O-R model, all behavioural outcomes involve a process of integrating of internal and eternal parts: the external interactive process of people with environment and the internal psychological process of acquisition and obtainment (Illeris, 2003). The external interactive process is the social dimension, such as perception and contact. It affects the integration of environment and individuals and changes people's behaviours. We believe that the stimuli perceived in the e-learning environment can be considered stimuli of the external environment and are correlated with the mental response generated in learning (subjective well-being) and self-efficacy. We therefore consider here how peer referent, perceived closeness and perceived control are related to students' mental response. An internal psychological process is a process where the cognitive function and subjective feeling interact with each other (Illeris, 2003), and here we divide the internal psychological process into two parts: self-efficacy and subjective well-being.

Research model and hypotheses

The S-O-R model can explain the willingness of students to engage in learning on their own initiative in the context of e-learning. To include the e-learning environment in the model as social environment stimuli, we assume that perceived control, perceived closeness and peer referents are positively correlated with the self-efficacy and subjective well-being of students, which in turn affects learning engagement in the e-learning context. Based on this, we have interconnected the set of theoretical constructs in the S-O-R model and elucidated the underlying mechanisms in the research model (Fig. 1).

Engagement in Learning

Learning engagement is the student behaviour of participating in learning activities for better acquiring knowledge or skills (Hu & Hui, 2012), and it is susceptible to the qualities of the learning environment. Learning engagement emphasizes the importance of behaviour (e.g. engagement), affection (e.g. well-being or satisfaction) and

cognitive engagement in learning (Lam, Wong, Yang, & Liu, 2012). It is one of the foremost factors for improving learning outcomes, as shown by many previous studies (Carini, Kuh, & Klein, 2006; Klem & Connell, 2004; McMahon & Portelli, 2004).

When students engage in learning on their own initiative, they take initiative in and/or concentrate on acquiring and applying new skills or knowledge, solve problems using underlying approaches and show a positive attitude towards their learning process (Deater-Deckard, Chang, & Evans, 2013). The development of models and measures that promote student learning engagement are crucial to the development of the field of education (Zahn, 1980). The more students engage in learning, the higher their enthusiasm for learning will be and the better progress they will make.
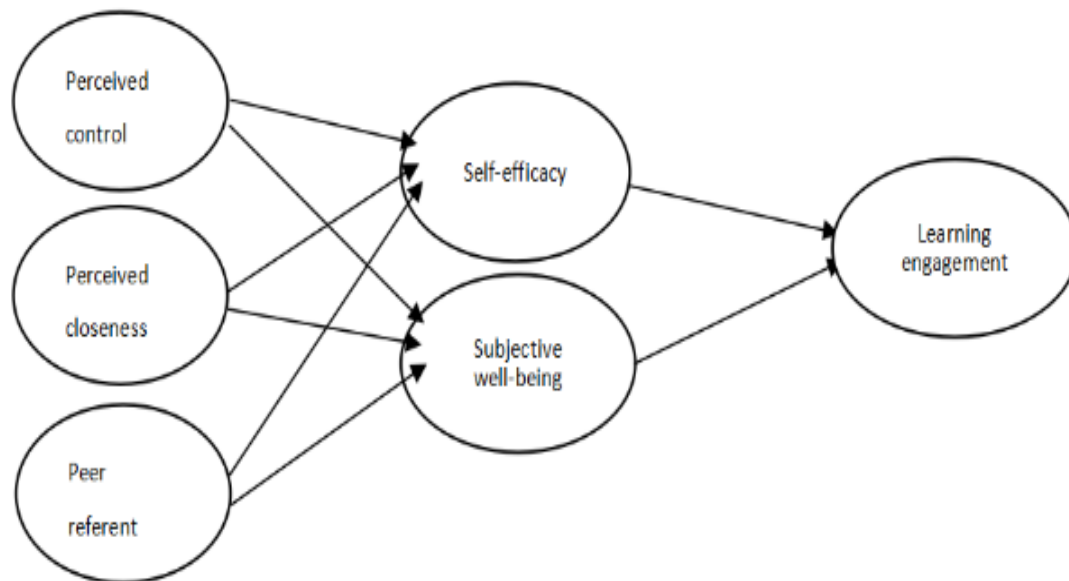

Figure 1. **Research framework**

Self-efficacy

Scholars argue that an individual's behavioural outcome is affected by environmental factors, in particular situation (Dinther, Dochy, & Segers, 2011), especially for those beliefs leading to success. This belief is called "self-efficacy" and it is an important cognitive variable used to explain personal factors in individual formative behaviour and interactions with the environment (Lent et al., 2014; Sheu, Chong, Chen, & Lin, 2014). Self-efficacy has been widely applied in the field of education to discuss students' psychological cognitive factors and the positive influence of their learning performance on career development. Contemporary studies hold that more research on the relationship between self-efficacy and learning performance improvement needs to be carried out (Tims, Bakker, & Derks, 2014). Tims et al. (2014) assert that when individuals have a high level of self-efficacy, they make more effort to obtain learning-related resources that can help them engage more deeply in learning (Bakker & Demerouti, 2014). It can thus be deduced that when students have a high level of self-efficacy, their learning engagement may be further

improved. Based on the above, this study makes the following hypothesis:

H1: Self-efficacy is positively correlated with learning engagement.

Subjective well-being

Subjective well-being is consistent well-being or satisfaction that allows individuals to feel successful and deal with life pressure (Diener & Seligman, 2004; Huppert & So, 2013). Students' subjective well-being often involves the quality of school teaching and a positive emotional and cognitive evaluation of the school (Scrimin, Moscardino, Altoè, & Mason, 2016). Subjective well-being is critical to successful learning engagement among college students, because it promotes active learning, critical thinking, optimal performance, learning participation and physical and mental health (Huppert & So, 2013; Steptoe, Deaton, & Stone, 2015). Given the situation resulting from the COVID-19 pandemic, in which colleges and universities in mainland China have been using e-learning instead of traditional in-person teaching models for an extended period of time, students can perceive the more informal environment and

are more self-centred (Tremayne, Chen, Figur, & Huang, 2008). Student well-being has a positive impact on accepting new knowledge, facing new challenges and maintaining learning motivation. Therefore, this study makes the following hypothesis:

H2: Subjective well-being is positively correlated with learning engagement.

Perceived control

Teaching classroom control is often defined as a single dimension ranging from teacher control to student autonomy, as well as teacher and student control of learning (DeCharms, 1976). Classroom control depends on the teaching content and direction, as controlled by teachers, and the opportunities for self-directed learning for students (Bandura & Wood, 1989). Connell (1985) holds that perceived control could be improved by providing students with opportunities for choice and self-directed learning. Pintrich and de Groot (1990) believe that learning outcomes depend on students' view of organized teaching, their specific learning goals and clear explanations. Learning autonomy is the major determinant in ensuring sustainable self-control and improving learning performance (Ames, 1992; Connell, 1985; Pintrich & de Groot, 1990). There is no conflict, however, between giving more decision-making power to students in class and preserving the teaching responsibilities of teachers (Randi & Corno, 2000). Eckles, Midgley, Wigfield, Buchanan, and Iver (1993) found that low sense of control among students may have an adverse effect on their intrinsic motivation and academic performance. The expectation for gaining higher levels of inner achievement is therefore related to a higher degree of student control. When teachers do not share classroom decisions with students – that is, in teaching based on teacher control – students tend to avoid self-regulating strategies (Eccles et al., 1993; Ryan & Grolnick, 1986). Students who think they have no substantial control over their learning will show a lower level of response. Giving students the opportunity to make choices can enhance their intrinsic motivation and their engagement in learning (Ryan,

Connell, & Deci, 1985; Zimmerman & Kitsantas, 1999). We can thus infer that students have the highest self-recognition and self-efficacy when they perceive the classroom environment as being mainly student controlled. We thus propose the following hypothesis:

H3: Perceived control is positively correlated with self-efficacy.

According to theoretical and empirical research, perception of autonomous control promotes a higher level of well-being, because respondents with autonomous control can easily meet their basic psychological needs (Deci, La Guardia, Moller, Scheiner, & Ryan, 2006; Deci & Ryan, 2008; Deci et al., 2001). Decades of research have shown that perceived control is associated with motivation and various happiness indexes, such as the parent-child relationship (Abad & Sheldon, 2008; Clark & Ladd, 2000) and friendship (Demir, Şimşek, & Procsal, 2013). This idea has also been applied to the teacher-student relationship: students' perceived control has been shown to promote the internal perception of learning (Bonneville-Roussy, Vallerand, & Bouffard, 2013; Filak & Sheldon, 2008; Overall, Deane, & Peterson, 2011; Sheldon & Krieger, 2007; Simon, Aulls, Dedic, Hubbard, & Hall, 2015). For example, in a study on law school students, Sheldon and Krieger (2007) show that students who believe teachers support their choices in the classroom have a higher GPA, higher ABA scores and more motivation for hunting jobs after graduation. In another study, Black and Deci (2000) show that the adoption of teaching strategies to promote student autonomy in class can support student success. Specifically, the students' perception of autonomous control from the teacher indicates inner satisfaction, increase of learning time and a more comprehensive command of the entire curriculum knowledge. Based on this, we suggest the following hypothesis:

H4: Perceived control has a positive effect on subjective well-being.

Perceived closeness

Perceived closeness is the sense of mutual trust and understanding generated from frequent interpersonal communication and pleasant interaction (Carey, 1986; Frisby & Martin, 2010; Gremler & Gwinner, 2000; Ryan, Wilson, & Pugh, 2011). When being applied in the relationship between teachers and students, it is interpreted as "the results of communication with teachers perceived by students" (Frisby, Mansson, & Kaufmann, 2014). Student self-efficacy in the teaching process depends on the individual characteristics of the teacher (Rots, Sabbe, & Aelterman, 2002). Studies have shown that students have the greatest motivation when they perceive a positive correlation with teachers (Connell & Wellborn, 1991; Ryan et al., 2000; Skinner & Belmont, 1993). The relationship between students and teachers is an important predictor of subjective well-being (Aelterman,

Engels, Van Petegem, & Pierre Verhaeghe, 2007). Building a strong supportive relationship with teachers makes students feel safer, more secure and more capable in the school environment, thus affecting intrinsic motivation (Olivier & Archambault, 2017). The behavioural motivation of students is closely related to the teacher's ability to encourage cooperation. Such cooperation will also affect the teaching results, including the students' perception of themselves in class. This perception is obvious, especially in collective communication (McCroskey, Richmond, & Bennett, 2006). Therefore, this study makes the following hypothesis:

H5: Perceived closeness has a positive effect on self-efficacy.

School is, in essence, a place of relationships. In this case, interpersonal relationships can have a positive or negative effect on student well-being (Bernard, Stephanou, & Urbach, 2007; Redmond, Skattebol, & Saunders, 2013). Kristja'nsson (2007) believes that affable people help to increase well-being by demonstrating lovely, positive and good manners. Students value teachers who try hard to build relationships with them (Pomeroy, 1999; Sellman, 2009) and those who are "affable, smart, and interesting" (Hutchings et al., 2008). Teachers can thus carry out effective practice in class by promoting teacher–student interaction and striving to support students' social and affective functions. Studies have shown that students' well-being score is very low if their teachers show uncertainty and dissatisfaction when students make presentations in class (Holfve-Sabel, 2008; Stevens & Sanchez, 1999). As Barton et al., (2000) emphasize, "Students generally spend a lot of time in school, and the quality of experience during the period of time with teachers is bound to affect emotional health." In the process of school teaching, students who are more emotionally connected with teachers show positive development trajectories in society and the academic sector (Hamre & Pianta, 2001; Harter, 1996; Ladd, Birch, & Buhs, 1999; Roeser, Eccles, & Sameroff, 2000; Ryan, Stiller, & Lynch, 1994). This can also be extended to a more extensive educational background. For example, in an e-learning environment, teacher–student closeness will affect student well-being. Therefore, this study makes the following hypothesis:

H6: Perceived closeness has a positive effect on subjective well-being.

Peer referents

Studies on point-to-point social impact in the student learning environment have shown that student characteristics and behaviour tend to concentrate spatially and temporally (Aral & Walker, 2011). The mechanism for this is generally considered to be peer influence or peer referents (Turner, 1991). Some scholars have proposed that people will be positively or negatively evaluated based on the compliance of their behaviours to their role and surroundings (Eagly & Karau, 2002), so the influencing process on interactive behaviour between peers cannot be ignored. Studies in the field of interpersonal relationships has repeatedly shown that peer referents plays an important role in influencing perception and behaviours; the more individuals observe peers engage in a certain behaviour, the more likely they are to engage in the same or similar activities (Bapna & Umyarov, 2015; Beams, Brown, & Killough, 2003). If students observe that many peers are engaging in e-learning, they are more likely to engage in the same (Chen, 2008). In terms of online herd behaviour, more peer referents tend to increase students' perception of themselves, and students further believe that their behaviours are recognized by their peers. Based on the above arguments, we make the following hypothesis:

H7: Peer referents have a positive effect on self-efficacy.

In a learning environment, peers have an obvious internal influence and may have an important influence on subjective well-being. Albanesi Cicognani, and Zani (2007) propose that relationships between peers can predict students' social well-being, because references between peers are intuitive for students. For example, if most of your friends agree about an idea, you may feel obliged to show your agreement. When an individual compares his or her own behaviour with that of a friend, subjective well-being will occur if his or her behaviour is recognized by that friend (Lord & DeZoort, 2001). In e-learning lectures, if the understanding of and ideas about knowledge a college student possesses are recognized by peers, a positive peer referent is generated. These referents are associated with student perception of well-being in the learning process. Grobecker (2016) believes that peer support has a positive impact on students' learning, motivation and confidence, so it has a bearing on students' subjective well-being. All of these arguments indicate that peer referents may be an important prerequisite for perceiving well-being. Based on the above arguments, we make the following hypothesis:

H8: Peer referents have a positive effect on subjective well-being.

Methods
Data collection

To contain the further spread of COVID-19, all colleges and universities in Mainland China have replaced traditional face-to-face teaching with e-learning in 2020. This study takes college students as the research subject, selected four universities in Mainland China and distributed 500 questionnaires. After sampling, a total of 377 questionnaires were collected, with an effective response rate of 75.4%. Because the senior students had entered the internship stage and no teaching courses were arranged, this study used freshmen, sophomores and juniors as the research subjects.

Instrument

The translation was improved and all inconsistencies were eliminated, thus to make the two English versions consistent.

We handed out 500 copies of questionnaire in total in four Chinese universities, To test the research model, a survey instrument was developed with each construct measured using multiple items. Most items were adapted from existing measures in the related literature with confirmed content validity and reliability, and then modified to fit our research context. Perceived closeness was measured by three items adapted from Ng (2013). Peer referents were measured by three items adapted from Eckles, Meslin, Gaffney, and Helft (2005). For perceived control, an extended form of the Student Decision-Making Scale (Eshel, 1991) was employed. This scale presented a student perspective on shared control in class. For self-efficacy, four items were selected on the basis of prior scale and item analyses of Asian applications. Subjective well-being was measured using Keyes's (2005) subjective well-being instrument (adolescent version). All items were measured with a five-point Likert scale (1 = totally disagree; 5 = totally agree).

Because data were collected in China, translation and back-translation were adopted to ensure the translation quality. First, we consulted three professors of linguistics to understand the significance and readability of each item. The English questionnaire was then translated into Chinese with their help. Second, the Chinese questionnaire was translated into English by two PhD candidates otherwise unconnected with this

study. Third, we compared the translated items with the original items in English. To ensure the consistency of the two English versions, we improved the translation and eliminated all inconsistencies.

A total of 500 questionnaires were distributed in four Chinese universities. Questionnaires were distributed and collected in May and June 2020, and a total of 422 questionnaires were received. Of these, 45 questionnaires were eliminated due to questions that were not answered, so the valid questionnaires numbered 377, resulting in a valid response rate of 75.4%. Male students accounted for 46.8% of respondents and female students for 53.2%; freshmen accounted for 35.6%, sophomores for 31.2% and juniors for 33.2%; students majoring in social science accounted for 56.1%, and students majoring in natural science for 44.9%; students from public universities accounted for 69.4%, and students from private universities for 31.6%. Because seniors had started their internships and had no more courses, this study only accepted freshmen, sophomores and juniors as respondents.

Results

In our data analysis, we used partial least squares (Smart PLS 3.0), a variance-based latent variable structural equation modelling (SEM) technique. The primary advantages of PLS-SEM include the relaxation of normal distributional assumptions required by the maximum likelihood method used to estimate models using CB-SEM, as well as PLS-SEM's ability to easily estimate much more complex models with smaller sample sizes (Hair, Risher, Sarstedt, & Ringle, 2019; Khan et al., 2019). The above reasons support the use of PLS at an appropriate SEM method for this study. Prior to evaluating the research model, we conducted several analyses to ensure that the latent constructs exhibited factorial validity and reliability. As shown in Table 1, all items show a high load for their relevant factors, but a low crossover load for other factors, indicating good convergence and discriminatory validity.

However, confirmatory factor analysis was carried out to evaluate reliability and validity. As shown in Table 2, Cronbach's α values ranged between 0.779 and 0.873, and the complex reliability (CR) values ranged from 0.858 to 0.913. All values are higher than the threshold value of 0.7, showing an adequate reliability. Moreover, the average variance (AVE) ranged from 0.604 to 0.725, which is higher than the suggested threshold value of 0.5. This indicates sufficient convergent validity (Fornell & Larcker, 1981). Third, this study compares the square root of the AVE and structural dependence to test the discriminant validity (Gefen & Straub, 2005). As shown in Table 3, all dependencies are lower than the square root of the AVE, showing a sufficient discriminant validity.

Table 1. **Factor loadings.**

	Peer referent	Perceived closeness	Learning engagement	Subjective well-being	Self-efficacy	Perceived control
peer referent1	**0.763**	0.297	0.243	0.290	0.309	0.182
peer referent2	**0.787**	0.299	0.250	0.249	0.338	0.241
peer referent3	**0.821**	0.280	0.230	0.302	0.397	0.144
peer referent4	**0.792**	0.185	0.250	0.368	0.407	0.326
perceived closeness1	0.299	**0.767**	0.249	0.224	0.216	0.191
perceived closeness2	0.232	**0.857**	0.263	0.311	0.207	0.201
perceived closeness3	0.232	**0.807**	0.177	0.231	0.167	0.166
perceived closeness4	0.335	**0.838**	0.233	0.249	0.208	0.247
Learning engagement1	0.286	0.200	**0.827**	0.524	0.415	0.381
Learning engagement2	0.237	0.215	**0.832**	0.584	0.437	0.315
Learning engagement3	0.279	0.305	**0.817**	0.565	0.379	0.344
Learning engagement4	0.203	0.193	**0.768**	0.376	0.230	0.275
Subjective well-being 1	0.267	0.192	0.524	**0.843**	0.446	0.412
Subjective well-being 2	0.318	0.214	0.529	**0.873**	0.447	0.370
Subjective well-being	0.258	0.230	0.567	**0.866**	0.415	0.401
Subjective well-being 4	0.378	0.318	0.476	**0.820**	0.542	0.404
Self-efficacy1	0.307	0.149	0.420	0.428	**0.763**	0.310
Self-efficacy2	0.405	0.232	0.344	0.500	**0.816**	0.322
Self-efficacy3	0.321	0.176	0.396	0.402	**0.810**	0.379
Self-efficacy4	0.390	0.198	0.223	0.438	**0.723**	0.251
perceived control1	0.215	0.200	0.323	0.371	0.338	**0.816**
perceived control2	0.228	0.237	0.334	0.376	0.344	**0.839**
perceived control3	0.265	0.197	0.319	0.391	0.316	**0.867**
perceived control4	0.244	0.202	0.387	0.470	0.372	**0.866**

Structure Model

We used the SRMS criterion to evaluate the model's goodness of fit. In our examples, the SRMS is 0.062, lower than the 0.08 proposed by Henseler, Hubona, and Ray (2016), indicating a satisfactory model fit. After evaluating that the measurement was satisfactory, we assessed the structural model. The hypotheses were examined by the percentage of variance explained and the significance of the structural paths. Figure 2 shows the test result of the PLS analysis including control variables. Perceived control (β=0.298, p<0.001) and peer referents (β=0.363, p<0.001) are positively correlated with self-efficacy, so H3 and H7 are supported. But perceived closeness (β=0.059, p=0.258) is not significant for self-efficacy, so H5 is not supported. Perceived control (β=0.156, p<0.01), perceived closeness (β=0.381, p<0.001) and peer referents (β=0.194, p<0.01) have a significantly positive correlation with subjective well-being, thus H4, H6 and H8 are supported. Self-efficacy

(β=0.172, p<0.01) and subjective well-being (β=0.553, p<0.001) are positively correlated with learning engagement, so H1 and H2 are supported.

Table 2. **Scale properties.**

Factor	Item	Standardized loading	VIF	Cronbach's alpha	Composite reliability	AVE
Perceived closeness				0.838	0.892	0.674
	perceived closeness	0.777	1.612			
	perceived closeness	0.879	2.220			
	perceived closeness	0.789	1.737			
	perceived closeness	0.834	2.029			
Perceived control				0.873	0.913	0.725
	perceived control	0.868	2.462			
	perceived control	0.879	2.431			
	perceived control	0.817	1.891			
	perceived control	0.841	2.075			
Peer referent				0.806	0.873	0.632
	peer referent	0.821	1.757			
	peer referent	0.744	1.564			
	peer referent	0.780	1.642			
	peer referent	0.831	1.847			
Self-efficacy				0.779	0.858	0.604
	Self-efficacy	0.791	1.749			
	Self-efficacy	0.829	1.801			
	Self-efficacy	0.822	1.831			
	Self-efficacy	0.655	1.384			
Subjective well-being				0.870	0.912	0.722
	Subjective well-being	0.872	2.923			
	Subjective well-being	0.883	3.106			
	Subjective well-being	0.876	2.434			
	Subjective well-being	0.763	1.548			
Learning engagement				0.826	0.885	0.659
	Learning engagement	0.848	2.462			
	Learning engagement	0.863	2.431			
	Learning engagement	0.841	1.891			
	Learning engagement	0.683	2.075			

Table 3. **Correlation matrix.**

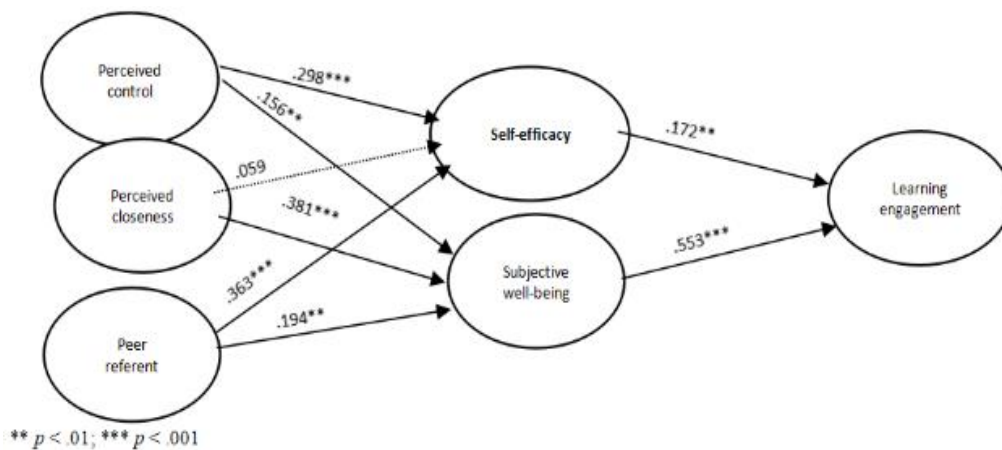|	Subjective well-being	Peer referent	Learning engagement	Perceived control	Perceived closeness	Self-efficacy
Subjective well-being	0.850					
Peer referent	0.362	0.795				
Learning engagement	0.644	0.346	0.812			
Perceived control	0.483	0.303	0.420	0.851		
Perceived closeness	0.327	0.339	0.309	0.277	0.821	
Self-efficacy	0.532	0.473	0.466	0.424	0.265	0.777

** $p < .01$; *** $p < .001$

Figure 2. **Structural model**

Discussion

The results of this study indicate that a harmonious relationship between teachers and students, peer referents among students, and student autonomous control over teaching contribute a lot to the learning engagement of students. With Chinese college students as the research sample, an empirical study was carried

out to explore the dependence relationship between perceived closeness, perceived control, peer referents, self-efficacy and subjective well-being and learning engagement using the S-O-R model. This study fills the theoretical gap in terms of research on student learning engagement in the e-learning context and will enhance theoretical generalizations.

Based on our findings, this study aims to make the following contributions. First, few studies have confirmed the influence of stimulating factors in e-learning environment on students' learning engagement. This study used the COVID-19 pandemic as the research background, discussed learning engagement among college students in the long-term e-learning process and attempted to provide practical inspiration for schools to carry out more e-learning practices in the future. Second, most of the previous studies on the S-O-R model focused on the importance of external environmental stimuli, but few studies have analysed the role of specific factors in e-learning. This study aimed to fill this gap and enrich the applications of the S-O-R model. Third, in addition to verifying the research framework established by the S-O-R model, this study also focused on the perspective of e-learning. Our research findings will provide more insights and suggestions for e-learning management.

The results of this study show that perceived closeness, perceived control and peer referents are positively correlated with subjective well-being. This signifies that, in the e-learning context, students' participation in and control of the teaching process, their high closeness with teachers and their mutual recognition and behavioural referents with peers will make students feel satisfied and thus produce learning-related well-being. The close relationship between teachers and students is one of the main factors affecting the psychological status of students, which is consistent with the results of previous research (Richmond, Berglund, Epelbaum, & Klein, 2015; Rogers, 2015). Perceived control and peer referents are positively correlated with self-efficacy. In other words, students perceive higher self-efficacy when students think that the teacher has given them

more freedom to make choices in class. In addition, the mutual effect and synchronized behaviour of peers is also an external influencing factor that has a positive effect on students' internal self-efficacy. This study also found that self-efficacy and subjective well-being are positively correlated with learning engagement. This is in line with prior findings; for example, Bandura and Wood (1989) stress the importance of self-efficacy for changing and using capabilities,

which is one of the factors for improving academic performance.

However, we also found that the relationship between perceived closeness and self-efficacy was not supported. Previous studies have put forward that this close relationship is one of the most significant factors that influence courses (Richmond et al., 2015; Rogers, 2015). Influence of this kind is not necessarily positive. In e-learning, changes in the learning environment and a long stay at home inevitably cause learning difficulties. Thus, when teachers have a harmonious relationship with students, students tend to depend on their teachers, thinking that teachers will recognize the learning difficulties and tolerate their inertia, which ultimately negatively affects their self-efficacy.

Practical implications

According to our findings, this study has important practical significance for learning engagement among college students in the e-learning context. A close relationship between teachers and students, students' autonomous control over class and mutual support and referents among peers are considered predictive factors for self-efficacy, subjective well-being and learning engagement. External environmental stimuli have an effect on psychological status and help students gain more positive inner feelings, so they can be regarded as an essential condition for improving student learning engagement. Teachers should focus on motivating students to engage in learning on their own initiative while asking them achieve goals. We therefore make the following suggestions for long-term study at home during the global COVID-19 pandemic. First, teachers should be encouraged to grant students more control over their learning, provide a more active online teaching atmosphere, add relevant applied technologies and enhance students' sense of participation and control in class. Some studies have indicated that teachers play an important role in guiding students to control their learning (Zimmerman, Bonner, & Kovach, 1996). Thus, schools should provide teachers with brief training

courses on how to promote these techniques in e-learning.

Second, teachers should support communication among students in the e-learning environment. Students are prone to be affected by the ideas of their peers, so teachers should increase opportunities for communication among students, creating a learning and social environment that is conducive to relationship maintenance and strengthens interaction. Moreover, providing more interfaces and functions for interaction and communication among students can also be introduced to the online teaching platform. Our findings not only can enrich the research on student interaction in e-learning, but also can help teachers and platforms that provide online courses in the future.

Third, teachers should develop good teacher–student relationships. This study suggests that teachers also need to state course requirements and objectives clearly to students while creating a close relationship to reduce environmental barriers. Teachers should pay close attention to the subtle changes in the teacher–student relationship in the network environment and observe the mental and learning states of students while teaching. Teachers should have a definite attitude towards student inertia and contain the development of adverse mental states in a timely manner.

Research Limitations

Our research findings will enrich the literature on learning engagement, the S-O-R model and e-learning environments. Nevertheless, some limitations exist and represent further research directions. First, although the S-O-R model has achieved a remarkable position in the field of psychology, only a few studies have focused on the relationship between stimulating factors in the e-learning environment and learning engagement among college students. This study builds the constructive mechanism for learning engagement in the e-learning environment based on the S-O-R model (perceived closeness, perceived control and peer referents), and extracts important learning theories, but considering the unique, long-term and large-scale e-learning environment generated by the COVID-19 pandemic, future research should test the model under different scenarios, such as e-learning as a supplement to face-to-face instruction.

Second, the data used in this study came from courses for a medium number of students (40–70 students), and no typical large-scale courses for audiences in the hundreds were involved. Thus, it remains to be seen whether student control over courses, harmonious teacher–student relationships and extensive peer referents in e-learning for a larger number of students can bring similar benefits.

Third, the sample in this study may not accurately represent all student groups due to the restrictions of time and space. Thus, future research should include and compare different ethnic and cultural groups to provide additional opinions on e-learning, in addition to expanding the sample size and improving the research representativeness.

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