



How to motivate student engagement in emergency online learning? Evidence from the COVID-19 situation

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Abstract

COVID-19 has caused the overnight migration of learning and teaching to online platforms and has significantly impacted students' learning opportunities and experiences worldwide. The results of emergency online learning have heavily relied on students' abilities to exercise agency in maintaining active motivation and engagement with online learning. Despite the wide application of motivation theories to diverse contexts, how to adapt motivation theories to develop online learning effectively and sustainably in complex and situational online learning environments is still under-investigated. Using a large sample of 14,935 postgraduate students from 31 universities in China, this study examined the effects of student motivation and engagement on students' academic achievement in the COVID-induced online learning anchored by the theoretical perspective of self-determination theory. This study made contribution to the self-determination theory by extending it to the complex emergency situation and supported its main argument that online emergency learning environments satisfying students' psychological needs of autonomy and competence promote optimal motivation, positive engagement and academic achievement. This study also contributed to reveal the 'sophisticated' nature of relatedness satisfaction in the case wherein its specific effects depend on the cultural configuration of the contexts and on the specific types of engagement. Given the fact that COVID-19 continues to be a public challenge throughout the world, implications for improving the quality of online teaching in the future were also discussed.

Keywords Student motivation · Engagement · Academic achievement · Online learning · COVID-19 pandemic

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Introduction

With the outbreak of COVID-19, educational systems have experienced an unprecedented disruption that has affected approximately 1.6 billion students worldwide (United Nations, 2020). At the higher education level, COVID-19 has caused the global lockdown of university campuses; as a result, university teachers have been thrust headlong into providing online courses and college students have been forced to learn online so that they can continue their education (Besser et al., 2020; Watermeyer et al., 2020). Although such an online migration has been regarded as a panacea for the COVID-19 shock to higher education, burgeoning evidence has reported the unprecedented challenges and obstacles experienced by universities, and university teachers and students (Dhawan, 2020; Watermeyer et al., 2020; Wu & Li, 2020; Zapata-Cuervo et al., 2021). Watermeyer et al.'s (2020) investigation of 1148 UK academics revealed that the abrupt transition to online provision caused significant uncontrollability, dysfunctionality and disturbance to their pedagogical roles. Wu and Li's (2020) survey, using a large sample covering 334 universities, 13,997 university teachers and 256,504 university students in China, reported that both teachers and students made little preparation for this exceedingly atypical circumstance. Zapata-Cuervo et al. (2021) summarised that mandatory online learning due to COVID-19 may generate concerns related to students' dissatisfaction, amotivation, disengagement and lower performance, all of which will severely affect the quality of online education.

Students' motivation and engagement for online learning during the pandemic need urgent investigation for both practical and theoretical reasons. First, empirical evidence suggests that effectively motivating and engaging students in the online classroom is critical to the quality and effectiveness of online education (Chen & Jang, 2010; Ferrer et al., 2020). However, the emergency online migration has given rise to unparalleled challenges concerning student learning experiences and outcomes, which might result in student learners' decreased motivation, lower satisfaction and poorer performance (Besser et al., 2020; Wu & Li, 2020; Zapata-Cuervo et al., 2021). Thus, it is necessary to explore how certain contextual factors during this situation promote or thwart students' motivation, and that this will in turn yield important effects on students' engagement and academic achievement when taking the mandatory online learning. Second, self-determination theory (SDT, hereafter) is one of the most comprehensive and empirically-supported theoretical frameworks for examining learner motivation in multiple contexts (Deci & Ryan, 2000). SDT consists of five interrelated mini-theories, including basic needs theory, organismic integration theory, goal contents theory, cognitive evaluation theory and causality orientation theory (Reeve, 2012). Motivation is examined from the perspective of basic needs theory within the framework of SDT in this study. According to SDT, motivation arises from multiple sources, including needs, cognition, emotions and environmental events (Reeve, 2012). Basic needs theory assumes that the concept of basic psychological needs specified the content and process of motivation (Deci & Ryan, 2000, 2008). Specifically, the overarching proposition of basic needs theory argues that motivation will be facilitated by environmental conditions that satisfy learners' psychological needs, whereas motivation will be undermined when conditions tend to thwart or neglect satisfaction of these innate psychological needs (Deci & Ryan, 2000; Vansteenkiste et al., 2020). For theoretical consideration, it warrants a thorough investigation of basic needs theory of SDT in an atypical emergency online migration environment, which helps extend the theory's tenability and applicability.

At present, the COVID-19 pandemic continues to be a public health threat for mankind, with no immediate end in sight (Adedoyin & Soykan, 2020). Thus, it has become a

pressing issue for educators, researchers and administrators to reflect on this emergency online migration and find ways to improve the quality of online teaching in the future. In addition, numerous factors have contributed to rising concerns that such an emergency situation could exacerbate differences in academic achievement between students from different ends of the socio-economic spectrum (Bacher-Hicks et al., 2021; Hodges et al., 2020). As the digital divide and educational equality become critical issues of online learning and a particular concern for online educators during the pandemic, it is also of pertinent importance to examine the group differences of online academic achievement across first-generation and non-first-generation students.

Although online learning received unprecedented attention during the COVID-19 outbreak, to the best of our knowledge, this study represents the first attempt to examine the effects of student motivation and engagement on students' academic achievement using the theoretical perspective of SDT. Given these empirical, practical and theoretical concerns, the current study focused on the following research goals. First, this study attempted to explore the extent to which emergency online migration has affected the satisfaction of Chinese postgraduate students' psychological needs as they tried to learn-as-usual during the pandemic period. Second, this study explored how students' perceptions of psychological needs satisfaction influence their learning engagement and academic achievement. Third, this study examined how this effect varied between first-generation and non-first-generation students.

Literature review

Self-determination theory and student engagement

Motivation lies at the core of human behaviours and concerns energy, direction and persistence of behaviours (Deci & Ryan, 2000). Specifically, the concept of motivation is used to describe those processes that can '(a) arouse and instigate behaviours; (b) give direction and purpose to behaviours; (c) continue to allow behaviours to persist; and (d) lead to choosing or preferring a particular behaviour' (Włodkowski, 1984, p. 12). Motivation is highly valued because of its consequences that motivation produces and countless motivation theories have been proposed to explain pertinent motivational behaviours, centering on its antecedents, consequences and processes (Cook & Artino, 2016; Deci & Ryan, 2008). Among diverse motivation theories, expectancy-value theory, attribution theory, social cognitive theory, goal orientation theory and self-determination theory have been summarised as the broadly recognized contemporary motivation theories (Cook & Artino, 2016). Each of them casts light on different aspects of motivation, contributing a unique perspective on motivation involving a host of personal, social and contextual variables (Cook & Artino, 2016; Reeve, 2012). Unlike other motivation theories, self-determination theory uses the concept of innate psychological needs to differentiate the content of goals and the regulatory processes through which outcomes are pursued (Deci & Ryan, 2000; Vansteenkiste et al., 2020). Basic needs theory of SDT identifies three innate psychological needs, namely, autonomy, competence and relatedness (Deci & Ryan, 2000, 2008; Vansteenkiste et al., 2020). Specifically, 'autonomy' refers to a sense of self-endorsement and volition, which means that individuals can freely initiate, maintain and regulate activities (Deci & Ryan, 2000, 2008). Meanwhile, 'competence' captures an individual's desire to have a sense of efficacy and capability

in activities and a feeling that he/she can complete challenging tasks and achieve satisfactory results (Deci & Ryan, 2000, 2008). ‘Relatedness’ refers to the psychological need for individuals to feel a sense of belongingness, connection and closeness with others during daily interactions (Deci & Ryan, 2000, 2008). Following Reeve’s (2012) suggestion, motivation is equated with psychological needs satisfaction within the perspective of basic needs theory of SDT.

‘Engagement’ refers to ‘the behavioural intensity and emotional quality of a person’s active involvement during a task’ (Reeve et al., 2004, p. 147). Student engagement can be regarded as a multidimensional and highly interrelated construct of behavioural, cognitive and emotional aspects of active involvement in various learning activities (Fredricks et al., 2004). Behavioural engagement mainly concerns the concentration, attention and effort exerted by students as they participate in learning activities (Fredricks et al., 2004; Kahu, 2013). Emotional engagement represents emotional responses of students towards teachers, peers and learning activities, and the presence of emotions that facilitates the completion of tasks (i.e., interest, enjoyment and value) or hinder their completion (i.e., distress, anxiety and pressure) (Fredricks et al., 2004; Kahu, 2013). Cognitive engagement mainly involves the extent of students’ mental investment in learning activities and intellectual efforts devoted to gaining mastery of learning contents through meta-cognitive strategies, such as goal setting, self-regulation and self-monitoring (Fredricks et al., 2004; Kahu, 2013). Accordingly, student engagement in online learning represents the behavioural efforts exerted by students in online learning and their psychological state of being emotionally and cognitively active as they strive to complete their courses. As mentioned by Pellas (2014), researchers’ increased interest in examining how students’ emotional, cognitive and behavioural engagement in online environments influences their learning outcomes constitutes a breakthrough in education research in recent years.

Basic needs theory contributes to the examination of student engagement in online learning activities in three important ways (Deci & Ryan, 2000, 2008; Hew, 2016; Reeve et al., 2004). First, this theory identifies the origins of students’ active engagement in learning activities in some cases and their passive or even antagonistic engagement in other cases. All of these can be attributed to either the satisfaction or the thwarting of their psychological needs in the learning environments. Second, this theory articulates the interplay between specific psychological needs and different manifestations of student engagement. Specifically, autonomy need satisfaction has been argued to provide a motivational basis for students’ behavioural, emotional and cognitive engagement. This is based on the reasonable assumption that the feeling of psychological freedom can drive students’ time and effort spent in learning activities in which they voluntarily participated as well as evoke their positive attitudes and feelings towards learning activities whilst stimulating their mental investment at the same time. Competence need satisfaction is considered as a critical motivating factor for students’ engagement in learning activities behaviourally, emotionally and cognitively. This is because having a sense of mastery and competence in accomplishing learning activities will encourage learners’ further behavioural and cognitive participation in learning activities as well as foster their positive feelings. Meanwhile, relatedness need satisfaction can also heighten students’ levels of behavioural, cognitive and emotional engagement. This is because learners’ frequent interactions with instructors and peers will facilitate their behavioural and cognitive investment in learning activities, which in turn, can lead to more positive emotions about learning activities. Third, this theory provides the basis for predicting a priori which aspects of the online learning environment will promote or undermine students’ engagement in online activities. This means that intervention

strategies can be taken in advance to focus on conditions that might affect students' satisfaction of autonomy, competence and relatedness in the online learning.

Online migration and student online learning in the COVID-19 era

Due to advancements in the Internet, technologies, learning platforms and tools in recent years, we have witnessed the rapid development of online education with its advantages of flexibility, availability, openness and low cost (de Barba et al., 2016; Sun et al., 2019). Notwithstanding the difficulty of a common definition, most researchers define 'online learning' as access to learning experiences via the use of technology (Moore et al., 2011). Accordingly, online learning is characterised by the utilisation of advanced technologies and new paradigms of pedagogical methods (Moore et al., 2011). Specifically, online learning differs considerably from traditional classroom learning in several ways: students interact with teachers, peers and contents online with the use of technologies whilst being physically separated and geographically isolated; students self-regulate and self-manage their learning process and learning activities in a self-paced environment, providing them with more autonomy to proceed at their own pace; and students can rely on rich sources of easily accessible contents found on the Internet and use a wide range of technology-based tools (Butz & Stupnisky, 2016; de Barba et al., 2016). Researchers have argued that it is more essential for learners in online learning environments to demonstrate higher levels of self-regulation, self-motivation and self-management compared to traditional on-site courses (Moore & Wang, 2020; Wang et al., 2019). In addition, contextual support from instructors and peers in online courses is critical for online learners (Hsu et al., 2019).

The COVID-19 pandemic has caused an unprecedented and devastating public health crisis with global impacts. The term 'emergency remote teaching' has been used to describe the circumstances under which educational institutions and educators made hurried moves to teaching online with bare minimum resources and scant time facing with the COVID-19 shock (Hodges et al., 2020). Given that the main objective during this situation is to provide temporary access to learning and instruction in ways that can quickly and reliably support individuals as they respond to an emergency crisis, rather than to re-establish a robust educational system, researchers pointed out that most cases of emergency remote teaching failed to conduct careful instructional design and planning (e.g., modality, pacing, pedagogy, interaction, assessments and feedback) to maximise online education's affordances and possibilities (Besser et al., 2020; Hodges et al., 2020). Online teaching is absolutely more than 'just getting it online', and ideally, instructors are supposed to adjust online courses based on characteristics of online learners and online learning environments.

Moreover, the expedient online migration during the COVID-19 pandemic has made student learning exceptionally demanding and stressful. Zapata-Cuervo et al.'s (2021) study showed that students experienced a sense of isolation, loneliness, anxiety and stress when the daily routines of on-site learning and daily lives have been completely disrupted. Ade-doyin and Soykan (2020) reported that the sudden onset of online learning that emerged during the pandemic is comparatively considered undesirable for many students. In particular, students have been burdened with more difficulties and challenges with online learning when the places sheltering them are less optimal, more likely to confine them in physical and psychological aspects, or hinder their learning and performance. Evidence shows that there exist significant differences in individuals' levels of adaptability and abilities to survive or thrive when faced with abrupt online migration situation (Besser et al., 2020). In

their study of 1217 Israeli college students, Besser et al. (2020) found that college students experienced significantly higher levels of stress and isolation and significantly lower levels of relatedness, concentration, motivation and performance when attending emergency COVID-induced online learning. Their study provided a descriptive analysis but failed to examine the interplay amongst relatedness, motivation and performance.

Effects of psychological need satisfaction on student engagement and academic achievement

Although motivation plays a crucial role in highly self-regulated learning environments, research concerning motivation in online learning is still at an early stage (Schumacher & Ifenthaler, 2018). Despite the noticeable research gap, an emerging line of studies has contributed to this body of knowledge by addressing the relationships amongst student learning motivation, engagement and academic achievement in the online environment. In one of the earliest studies, Chen and Jang (2010) reported that student motivation failed to predict any learning outcomes, including engagement and achievement, in the online context. In comparison, Hsu et al. (2019) re-examined Chen and Jang's (2010) model and found a significant relation between self-determined motivation and course grade using a sample of 330 undergraduate students attending seven online courses. Similarly, Butz and Stupnisky (2016) investigated 118 students undergoing synchronous hybrid learning and reported significantly large and positive correlations between perceived success and the needs satisfaction of autonomy, competence and relatedness. Wang et al. (2019) compared online and face-to-face classes and found that satisfaction of autonomy, relatedness and competence had positive effects on undergraduate students' grades. Emerging studies have reported the different effects of different kinds of needs satisfaction on academic achievement. For example, Deci and Ryan (2008) concluded that autonomy and competence have a much larger effect on student engagement and academic achievement than relatedness. In contrast, some researchers have argued that autonomy is not applicable to the Asian context in which societal culture is predominantly collectivist (e.g., Markus et al., 1996).

The relationships between student motivation and academic achievement have been documented in the literature, and studies have begun to examine the mechanisms and processes through which the impacts of motivation occur. With reference to the SDT framework, the current study aimed to explore the specific mediating role of student engagement in enabling motivation to influence students' academic achievement. SDT articulates an explicit and direct relationship between motivation and engagement, focusing on rich sources of motivation that lead to and/or facilitate engagement (Deci & Ryan, 2000; Reeve, 2012). Furthermore, student engagement is considered a prerequisite for online learning, during which students themselves, along with their teachers and peers, are geographically isolated from one another (Hew, 2016). In addition, previous studies on both on-site and online learning contexts have indicated the short- and long-term impacts of engagement on students (e.g. Pellas, 2014; Raes et al., 2020; Reeve, 2012). Student engagement has been found to predict grades and conducts in schools in the short term (e.g. Ferrer et al., 2020; Raes et al., 2020), whilst it has been linked to individual academic achievement, self-esteem and socially appropriate behaviours in the long term (e.g. Raes et al., 2020; Sun et al., 2019). In the context of emergency situation, it becomes

a pressing challenge for students to engage in online learning (Besser et al., 2020; Watermeyer et al., 2020).

Given the need to a quick transition to online learning, existing literature has focused on students' adaptability to such an online migration (Besser et al., 2020); challenges and opportunities faced by students during crisis-response online migration (Adedoyin & Soykan, 2020); the analysis of online learning's strengths, weaknesses, opportunities and challenges in the time of crisis (Dhawan, 2020); and students' perceptions of emergency online learning experiences (Wu & Li, 2020). Despite these observations, the literature has not yet probed into the core elements that influence students' learning experiences and outcomes. Specifically, researchers have not yet examined the relationships amongst student motivation, engagement and academic achievement in the context of emergency online migration. Understanding the nuanced dynamics of student motivation and engagement is the basis for designing effective educational interventions and quality online education. Therefore, there is an urgent need to examine how the emergency online environment can support or frustrate students' psychological needs for autonomy, competence and relatedness, and how the satisfaction of psychological needs facilitates students' behavioural, cognitive and emotional engagement in the learning process and activities, and all of which finally serve to predict students' academic achievement.

In addition, researchers have highlighted the pre-COVID academic inequality resulting from a digital divide across students from diverse socio-economic backgrounds (e.g. Bacher-Hicks et al., 2021; Hodges et al., 2020; Wu & Li, 2020). For instance, prior studies (e.g. Williams & Hellman, 2004) found that first-generation college students may lack sufficient motivation, engagement and self-regulation skills needed to perform successfully in online learning. Currently, some scholars have argued that numerous factors including students' access to and proficiency in the use of digital technologies, students' skills and experiences to learn within a self-regulated, self-managed and self-paced online environment, and teachers' preparedness, capabilities and pedagogical practices in online teaching, will exacerbate academic inequality in the COVID-induced emergency online learning (e.g. Bacher-Hicks et al., 2021; Hodges et al., 2020; Wu & Li, 2020). Since the academic inequality may widen by the emergency case, empirical evidence is urgently needed to investigate this enduring alarming issue surrounding online learning.

Thus, to address this research gap, we proposed the following hypotheses based on the above-mentioned research questions and the literature review.

H1: Each of these three dimensions of students' perceptions of psychological needs satisfaction is positively correlated with their academic achievement in the emergency online learning.

H2: Each of these three dimensions of student engagement is positively correlated with their academic achievement in the emergency online learning.

H3: Each of these three dimensions of students' perceptions of psychological needs satisfaction is positively correlated with each of these three dimensions of their engagement in the emergency online learning, respectively.

H4: Each of these three dimensions of student engagement mediates the effects of students' perceptions of psychological needs satisfaction on their academic achievement in the emergency online learning, respectively.

H5: The relationships between psychological needs satisfaction and academic achievement vary across the first-generation and non-first-generation college students in the emergency online learning.

Research method

Data and samples

As the first country unexpectedly hit by the COVID-19 outbreak, China took the lead in transforming on-site education into online education on a national scale. To prevent COVID-19 from spreading through educational institutions and to ensure the health and safety of teachers and students, as early as January 29, 2020, the Chinese Ministry of Education issued a notice requiring schools and universities to postpone the start of the spring semester of 2020. According to the statistics of the Ministry of Education, 1454 universities in China provided 12.26 million online courses for 2.3 billion college students during the pandemic period, creating a new peak of online teaching in history (The Ministry of Education, 2020). Metropolis cities, such as Beijing and Shanghai, took the lead in actively responding to the national call of ‘suspending classes but continuing teaching and learning’ during the pandemic. They urged schools and universities to fully convert to online teaching. The current study was part of a large survey on the Online Teaching & Learning of Postgraduate Students conducted by the Shanghai Municipal Education Commission via an online questionnaire. Out of 39 public universities in Shanghai, 31 agreed to voluntarily participate in this survey at the end of the semester (June, 2020) when students were invited to make a comprehensive assessment of their emergency online learning experiences. We collected 19,744 responses with a response rate of 7.5%, and 14,935 were finally identified as valid. A good representativeness resulted from the prominent role of educational institutions in Shanghai, as well as the large-scale sampling conducted for this study. The basic information of the sample is shown in Table 1.

Measures

This study consisted of three scales that measured the participants’ perceptions of needs satisfaction, engagement and academic achievement, respectively, during the emergency online learning. All scales were repeatedly tested in prior studies and were found to have acceptable reliability and validity. We also collected demographic information concerning the participants (i.e., gender, university affiliation, discipline, study program) and the online courses (i.e., course type, class size and course duration). Additionally, we adopted back-translation and expert-driven pre-test techniques to assure the instruments’ accuracy and quality in the Chinese context. A pilot study with 398 participants was conducted to validate these instruments, and the results showed satisfactory internal reliability and construct validity.

Psychological needs satisfaction The Basic Psychological Needs Scale, comprising ten positively worded items and eight negatively worded items (Van den Broeck et al., 2010), has been widely used to measure psychological needs in different studies. Considering that the mix of positively and negatively worded items may cause unexplained shared common variance as well as distinctive interpretations (Johnston & Finney, 2010), the current study adopted the version featuring ten positively worded items to measure students’ perceptions of psychological needs satisfaction during the emergency online learning. The validated scale was administered to the participants, who were asked to answer all items using a 5-point Likert scale anchored by strongly disagree (1) and (5) strongly agree. Sample items included ‘I really liked to interact with teachers and peers in online courses’ (relatedness),

Table 1 The basic information of the participants ($N = 14,935$)

Measures	Items	N	Percent (%)	Measures	Items	N	Percent (%)
University affiliation	Double first-class universities	5462	36.6	Course type	Theory courses	13,027	87.2
	First-class discipline universities	4002	26.8		Practical courses	725	4.9
	Non “double first-class” universities	5471	36.6		Compulsory ideological and political courses	520	3.5
Discipline	Social science	5084	34.0	Course size	Compulsory language courses	473	3.2
	Engineering	5027	33.7		Other compulsory courses	190	1.3
	Natural science	2263	15.2		Small (<20)	3593	24.1
	Humanities	2561	17.1		Medium (20–60)	8418	56.4
Program	Master students	13,843	92.7	Large (>60)	2924	19.6	
	Doctoral students	1092	7.3	Course duration	Less than 45 mins per lesson	959	6.4
Gender	Female	9280	62.1		45–89 mins per lesson	3961	26.5
	Male	5655	37.9		90–135 mins per lesson	6518	43.6
				More than 135 mins per lesson	3497	23.4	

Since 2017, the Chinese government has launched the Double First-Class initiative in order to build prestigious and competitive world-class universities and disciplines by the end of 2050. Overall, there were 42 double first-class universities and 95 first-class discipline universities being supported by this initiative in China, and Shanghai has 4 double first-class universities and 10 first-class discipline universities

'I felt a sense of accomplishment from online courses' (competence) and 'I was free to express my ideas and opinions in courses' (autonomy).

Student engagement The measurement of student engagement originated from the scale developed by Fredricks et al. (2005) to measure postgraduate students' engagement in a distance education setting. After deleting the items deemed inappropriate for measuring student engagement in an online environment, online engagement in this study included (1) behavioural engagement (BE), consisting of four items (e.g. 'I took notes carefully when I took an online course'); (2) cognitive engagement (CE), consisting of three items (e.g. 'I tried to search for some course-related information to deeply understand the course content'); and (3) emotional engagement (EE), consisting of four items (e.g. 'I felt happy when taking the online course'). The negatively worded items were reverse-coded. The items were scored on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Academic achievement The five-item academic achievement scale adapted from the Course Experience Questionnaire and Chinese College Teaching & Learning Survey (Wilson et al., 1997) was used to assess the postgraduate students' mastery of knowledge and skills in online courses. These five items were scored on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

First-generation and non-first-generation students First-generation students are defined as being from a family in which no parent or guardian has earned a baccalaureate degree, and as long as one of their parents or guardians has a baccalaureate degree, they are categorised as non-first-generation students.

Control variables In this study, we included information about postgraduate students and online courses (i.e., gender, university affiliation, discipline, study program, course type, class size and course duration) as control variables to eliminate the potential confounding effects on relationships between psychological needs satisfaction and online engagement and academic achievement.

Data analysis

With the aid of SPSS 22.0 and Amos 21.0 software, we performed two-step structural modelling using the method of maximum likelihood estimation. In the first stage of confirmatory factor analysis (CFA), we assessed the measurement model by evaluating the estimates of internal consistency reliability and convergent and discriminant validity. Following the suggestion of Fornell and Larcker (1981), satisfactory levels of composite reliability and average variance extracted (AVE) to measure internal consistency reliability and convergent validity should exceed 0.70 and 0.50, respectively. Discriminant validity was determined using the Fornell–Larcker criterion: the AVE of each construct should be larger than the inter-construct squared correlation (Fornell & Larcker, 1981).

In the second stage, we performed a path analysis to examine the effects of students' perceptions of psychological needs satisfaction on online engagement and academic achievement. Following the suggestion of Hu and Bentler (1999), a series of indices were adopted as the criteria for acceptable model fit, including the goodness-of-fit index (GFI, > 0.90), adjusted goodness-of-fit index (AGFI, > 0.90), Tucker–Lewis index (TLI, > 0.90),

comparative fit index (CFI, > 0.90), standardised root mean square residual (SRMR, < 0.08) and root mean square error of approximation (RMSEA, < 0.10). The chi-square estimate is highly sensitive to the sample size; thus, it would not be appropriate to use the chi-square to degree of freedom ratio as a model fit index in this study (Hu & Bentler, 1999). For the mediation analysis, a bias-corrected bootstrapping method with 5000 resampling times was used for examining the mediating significance as well as calculating the 95% confidence intervals.

Finally, we performed a multi-group analysis to identify the differences in the path coefficients amongst models for the first-generation and non-first-generation groups. Following Cheung and Rensvold's (2002) suggestion, measurement invariance regarding factor loading matrices was tested before assessing the invariance for path coefficients. Specifically, the unconstrained model was sequentially compared with the constrained measurement weights model and the constrained structural weights model to evaluate the invariance between the first-generation and non-first-generation groups. The statistical significance of invariance was rejected when a change in CFI between the previous and the new models is greater than 0.01 (Cheung & Rensvold, 2002). The chi-square difference was not applicable because of the large-scale sample used in this study.

Findings

Preliminary analyses

The data screening and preliminary analyses of missing values, outliers, normality, collinearity and common method variance test were carried out. The multivariate normality was tested, and the results of all variables' skewness and kurtosis values were lower than 1, following the normal distribution needed for SEM. Collinearity was assessed through a test of variance inflation factors (VIF). The results ranged from 1.167 (behavioural engagement) to 2.827 (autonomy satisfaction), indicating acceptable conditions to conduct regression analysis. In addition, Harman's single factor test was conducted to assess whether a common method bias existed in the data. The results showed that the total variance for a single factor was 35.655%, thus indicating that common method bias had no influence on the data.

Measurement model

Table 2 provided the detailed factor loadings, composite reliabilities, square root of AVE and correlations amongst the constructs. All items showed moderate to strong factor loadings, ranging from 0.585 to 0.943. The composite reliability of all the variables ranged from 0.809 to 0.937, with all estimates exceeding an acceptable level of 0.70. The AVE estimates in this study ranged from 0.518 to 0.794, with all the estimates surpassing the 0.50 critical value, thus providing evidence of convergent validity. Furthermore, the AVE estimates for each construct were larger than the inter-construct squared correlation, thus supporting the discriminant validity of all variables.

In addition to the saturated variables of autonomy satisfaction, relatedness satisfaction and cognitive engagement, the CFA results indicated an acceptable model fit in terms of perceived competence ($\chi^2 = 126.104$, $df = 2$, GFI = 0.996, AGFI = 0.979, TLI = 0.992, CFI = 0.997, RMSEA = 0.064 and SRMR = 0.0065), behavioural engagement ($\chi^2 = 20.084$,

Table 2 Standardized factorial loading, composite reliability, correlations and square root of AVE

	Std.FL	CR	AVE	RS	CS	AS	BE	CE	EE	AA
RS	0.585–0.943	0.815	0.604	0.777						
CS	0.797–0.909	0.897	0.745	0.073***	0.863					
AS	0.834–0.918	0.930	0.768	0.045***	0.755***	0.876				
BE	0.598–0.835	0.809	0.518	0.139***	0.265***	0.314***	0.720			
CE	0.863–0.928	0.920	0.794	-0.033***	0.680***	0.697***	0.210***	0.891		
EE	0.658–0.876	0.871	0.631	0.535***	0.310***	0.297***	0.294***	0.219***	0.794	
AA	0.811–0.910	0.937	0.747	0.120***	0.434***	0.423***	0.297***	0.399***	0.280***	0.864
Mean	-	-	-	2.798	3.615	3.531	2.914	3.704	2.553	3.403
SD	-	-	-	0.857	0.673	0.661	0.737	0.656	0.686	0.694

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Square root of AVE in bold on diagonals; off diagonals are Pearson correlation of constructs. *Std.FL* standardized factorial loading, *CR* composite reliability, *AVE* average of variance extracted; *RS* relatedness satisfaction, *CS* competence satisfaction, *AS* autonomy satisfaction, *BE* behavioural engagement, *CE* cognitive engagement, *EE* emotional engagement, *AA* academic achievement

$df=2$, GFI=0.999, AGFI=0.997, TLI=0.997, CFI=0.999, RMSEA=0.025 and SRMR=0.0058), emotional engagement ($\chi^2=105.274$, $df=2$, GFI=0.997, AGFI=0.983, TLI=0.990, CFI=0.997, RMSEA=0.059 and SRMR=0.0413) and academic achievement ($\chi^2=52.637$, $df=5$, GFI=0.980, AGFI=0.941, TLI=0.976, CFI=0.988, RMSEA=0.100 and SRMR=0.0155). Overall, the above-mentioned results provided sufficient support for the models, thereby allowing us to proceed with the evaluation of the structural model and conduct detailed hypotheses testing.

Descriptive statistics and correlations

Table 2 showed the means, standard deviations and correlations amongst all variables. The mean scores showed a relatively lower level of relatedness satisfaction ($M=2.798$, $SD=0.857$) compared with the levels of competence satisfaction ($M=3.615$, $SD=0.673$) and autonomy satisfaction ($M=3.531$, $SD=0.661$). The mean scores also illustrated a relatively lower level of emotional engagement ($M=2.553$, $SD=0.686$) compared with the levels of behavioural engagement ($M=2.914$, $SD=0.737$) and cognitive engagement ($M=3.704$, $SD=0.656$). Moreover, the mean score of academic achievement ($M=3.403$, $SD=0.694$) was relatively high on a 5-point scale. As shown in Table 2, the correlation between any two variables was significant. Although the results were not displayed in the table, each control variable was significantly correlated with one another. Therefore, control variables containing the participants' demographic information (i.e., gender, university affiliation, discipline and study program) and the online courses' information (i.e., course type, course size and course duration) were included in the subsequent path analysis.

Structural model

The overall path model (Fig. 1) yielded the following results: $\chi^2=13,434.858$, $df=456$, GFI=0.944, AGFI=0.931, TLI=0.945, CFI=0.952, RMSEA=0.044 and SRMR=0.039, indicating a good fit to the sample data. As shown in Fig. 1 and Table 3, relatedness satisfaction was significantly positively correlated with behavioural engagement ($\beta=0.172$, $p<0.001$) and emotional engagement ($\beta=0.606$, $p<0.001$), but was significantly negatively correlated with cognitive engagement ($\beta=-0.062$, $p<0.001$). In comparison, relatedness satisfaction did not generate significant effect on postgraduate students' academic achievement ($\beta=0.009$, $p>0.05$). Moreover, competence satisfaction was significantly positively related with behavioural engagement ($\beta=0.103$, $p<0.001$), cognitive engagement ($\beta=0.416$, $p<0.001$), emotional engagement ($\beta=0.171$, $p<0.001$) and academic achievement ($\beta=0.219$, $p<0.001$). Similarly, autonomy satisfaction was significantly positively related with behavioural engagement ($\beta=0.248$, $p<0.001$), cognitive engagement ($\beta=0.418$, $p<0.001$), emotional engagement ($\beta=0.151$, $p<0.001$) and academic achievement ($\beta=0.065$, $p<0.001$). Furthermore, behavioural engagement was positively related with academic achievement ($\beta=0.180$, $p<0.001$), cognitive engagement ($\beta=0.136$, $p<0.001$) and emotional engagement ($\beta=0.125$, $p<0.001$), respectively.

Mediation analysis

Table 4 indicated the significant mediating effects of behavioural engagement between students' perceptions of psychological needs satisfaction and academic achievement.

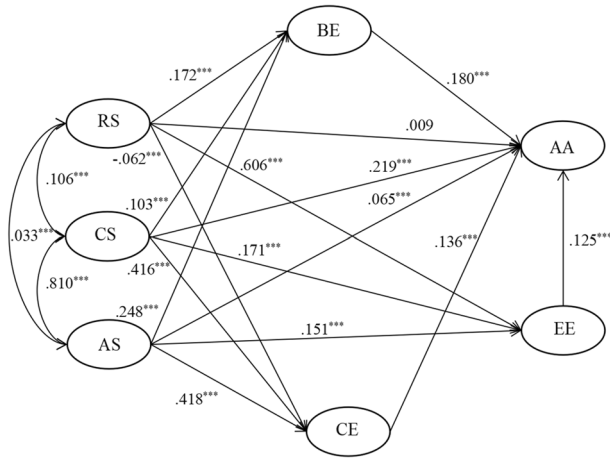


Fig. 1 Results of the SEM model. Note: Standardized coefficient was reported. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. RS, relatedness satisfaction; CS, competence satisfaction; AS, autonomy satisfaction; BE, behavioural engagement; CE, cognitive engagement; EE, emotional engagement; AA, academic achievement. Model fit indices: $\chi^2 = 13,434.858$, $df = 456$, $GFI = 0.944$, $AGFI = 0.931$, $TLI = 0.945$, $CFI = 0.952$, $RMSEA = 0.044$ and $SRMR = 0.039$. Controlling variables (i.e., gender, university affiliation, discipline, program, course type, course size and course duration) were included

Table 3 Path coefficients of the structural model

	BE		CE		EE		AA	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
RS	0.172***	0.012	−0.062***	0.007	0.606***	0.017	0.009	0.013
CS	0.103***	0.018	0.416***	0.012	0.171***	0.019	0.219***	0.016
AS	0.248***	0.019	0.418***	0.013	0.151***	0.020	0.065***	0.017
BE							0.180***	0.009
CE							0.136***	0.014
EE							0.125***	0.009

Standardized coefficient was reported. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. RS relatedness satisfaction, CS competence satisfaction, AS autonomy satisfaction, BE behavioural engagement, CE cognitive engagement, EE emotional engagement, AA academic achievement. Model fit indices: $\chi^2 = 13,434.858$, $df = 456$, $GFI = 0.944$, $AGFI = 0.931$, $TLI = 0.945$, $CFI = 0.952$, $RMSEA = 0.044$ and $SRMR = 0.039$

Similarly, the results demonstrated the significant mediating effects of emotional engagement between students’ perceptions of psychological needs satisfaction and academic achievement. Cognitive engagement was reported to have significant mediating effects between autonomy satisfaction and academic achievement and between competence satisfaction and academic achievement. On the contrary, the absolute value of total effect of relatedness satisfaction on academic achievement (0.000) was smaller than the absolute value of direct effect (0.010), revealing that cognitive engagement had suppressing effect between relatedness satisfaction and academic achievement rather than mediating effect (MacKinnon et al., 2000).

Table 4 The mediation effects of behavioural engagement, cognitive engagement and emotional engagement

	Indirect effects				Direct effects				Total effects			
	Coefficient	SE	BC 95%CI		Coefficient	SE	BC 95%CI		Coefficient	SE	BC 95%CI	
			Lower	Upper			Lower	Upper			Lower	Upper
RS-BE-AA	0.037	0.003	0.032	0.041	0.010	0.014	-0.012	0.032	0.047	0.014	0.024	0.070
RS-CE-AA	-0.010	0.001	-0.013	-0.008					0.000	0.014	-0.022	0.023
RS-EE-AA	0.089	0.010	0.075	0.105					0.099	0.010	0.085	0.116
CS-BE-AA	0.018	0.004	0.012	0.025	0.217	0.017	0.189	0.245	0.236	0.017	0.208	0.266
CS-CE-AA	0.056	0.007	0.044	0.066					0.274	0.015	0.245	0.300
CS-EE-AA	0.021	0.003	0.016	0.026					0.239	0.017	0.211	0.267
AS-BE-AA	0.048	0.005	0.041	0.056	0.069	0.018	0.038	0.097	0.116	0.018	0.085	0.145
AS-CE-AA	0.060	0.007	0.050	0.073					0.129	0.017	0.101	0.156
AS-EE-AA	0.020	0.003	0.015	0.026					0.089	0.018	0.057	0.116

Standardized coefficient was reported. *BC* bias-corrected bootstrapping, *RS* relatedness satisfaction, *CS* competence satisfaction, *AS* autonomy satisfaction, *BE* behavioural engagement, *CE* cognitive engagement, *EE* emotional engagement, *AA* academic achievement

Multi-group analysis

Table 5 presented the results of a multi-group analysis across the first-generation and non-first-generation groups. The fit of the unconstrained model ($\chi^2 = 13,933.922$, $df = 912$, $p < 0.001$, $GFI = 0.942$, $AGFI = 0.929$, $TLI = 0.944$, $CFI = 0.952$, $RMSEA = 0.031$ and $SRMR = 0.0392$) was satisfactory. The results showed that CFI did not decrease significantly after progressively adding the constraints of equal factor loadings (model 2), equal structural coefficients (model 3), equal structural covariance (model 4), equal structural residuals (model 5) and equal measurement residuals (model 6). In other words, the path coefficients from students' perceptions of psychological needs satisfaction to online engagement and academic achievement were invariant between first-generation and non-first-generation groups of postgraduate students.

Discussion and conclusion

Universities across the globe have made impressive efforts to move teaching online and attempted to proceed with teaching-as-usual when COVID-19 completely swirled our daily lives. As COVID-19 continues to be a prolonged public threat throughout the world, it is of particular concern to reflect on the accumulated emergency online migration experiences and explore ways by which to improve the quality of online teaching in the future. Using a large sample of 14,935 participants situated in the Chinese context, this study empirically tested a SDT-driven model depicting the relationships amongst students' perceptions of psychological needs satisfaction, engagement and academic achievement during COVID-induced emergency online learning (Fig. 2). The results partially supported Hypotheses 1–4 but rejected Hypothesis 5. The results of descriptive analysis and correlation analysis will be discussed, followed by the discussion of results of structural model, mediation analysis and multi-group analysis.

First, the current study revealed a relatively high level of autonomy satisfaction, which means that postgraduate students at Chinese universities benefited from having their autonomy supported during the emergency online learning. This finding is in contrast to the argument forwarded by some cross-cultural researchers that the psychological need for autonomy is not applicable to the Eastern collectivistic culture (Markus et al., 1996) and that the emergency online learning environment is completely in conflict with students' needs for autonomy and self-determination (Hodges et al., 2020). However, this finding echoes the statement that autonomy should be emphasised as an attainment or an attribute for postgraduate students to help them self-regulate and self-manage their online learning activities (Wu & Li, 2020). This study also showed that the level of relatedness satisfaction was substantially lower than those of competence satisfaction and autonomy satisfaction. This reinforces the idea that relatedness satisfaction is a particular concern in the emergency context, wherein teachers, students and peers made hurried moves to continue to learn-as-usual whilst being geographically isolated from one another. The level of cognitive engagement in this study was considerably higher than those of behavioural engagement and emotional engagement, which is in line with the prior finding that university teachers prioritised student cognition but neglected students' emotional responses in the emergency online learning context (Wu & Li, 2020).

Table 5 Invariance tests between first-generation and non-first-generation students

	χ^2	<i>df</i>	χ^2/df	TLI	CFI	ΔCFI	RMSEA	SRMR	Model comparison
Model 1	13,933.922	912	15.278	0.944	0.952	-	0.031	0.039	-
Model 2	13,968.926	931	15.004	0.945	0.952	0.000	0.031	0.039	2 vs. 1
Model 3	14,089.764	974	14.466	0.947	0.951	0.001	0.030	0.041	3 vs. 2
Model 4	14,490.149	987	14.681	0.947	0.950	0.001	0.030	0.041	4 vs. 3
Model 5	14,513.909	991	14.646	0.947	0.950	0.000	0.030	0.041	5 vs. 4
Model 6	14,933.313	1017	14.684	0.947	0.948	0.002	0.030	0.041	6 vs. 5

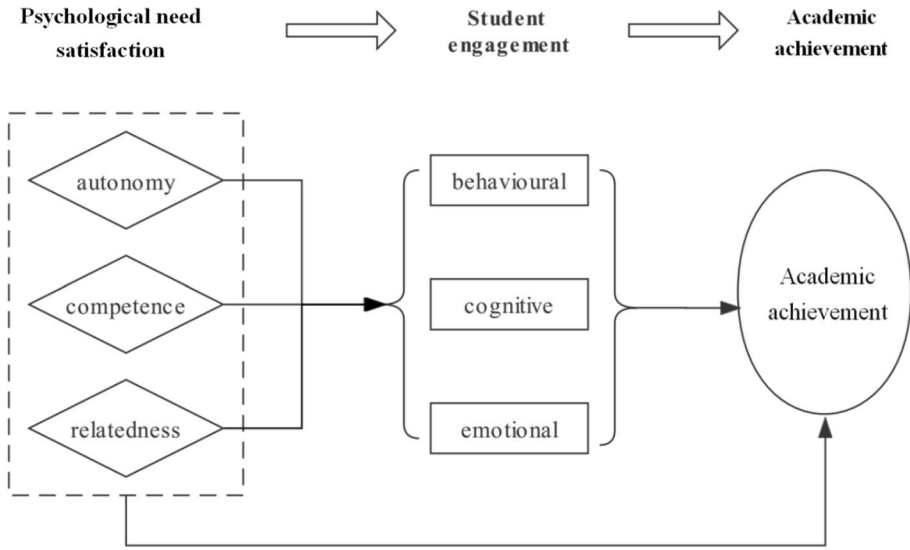


Fig. 2 The relationships between psychological needs and satisfaction, student engagement and academic achievement

This study demonstrated a strong link between autonomy satisfaction and competence satisfaction, which reflects the nature of relationships amongst these three psychological needs satisfaction that are both distinguished and interrelated (Deci & Ryan, 2000; Vansteenkiste et al., 2020). It can be explained that the time and effort students willingly devoted to online learning activities will help them achieve a strong sense of mastery and efficacy in interacting with the online learning environment. At the same time, it bears the potential to promote a strong sense of psychological freedom when students are learning more effectively and competently online. This study also showed that students' perceptions of autonomy satisfaction and competence satisfaction are highly correlated with their cognitive engagement. Students' perceptions of autonomy support in the online learning environment give them more latitude to choose learning goals, learning resources, and learning strategies, which might encourage them to invest more willingness and thoughtfulness to master difficult skills, understand complex ideas and use deep learning strategies (Hew, 2016; Reeve, 2012; Reeve et al., 2004). In addition, when students feel competent and effective in online learning, it is a natural process for them tend to use deep learning strategies (e.g. elaboration, planning, reasoning and critical thinking) instead of superficial learning strategies such as memorisation when dealing with online learning activities (Hew, 2016; Reeve et al., 2004).

Moreover, this study revealed positive significant correlations between relatedness satisfaction and behavioural and emotional engagement, but a negative significant correlation between relatedness satisfaction and cognitive engagement. These results consolidate the argument that autonomy and competence are more dominant in influencing learning processes and outcomes, whilst relatedness is still important but not to the same extent (Deci & Ryan, 2008). In line with the findings in the literature (e.g. Ferrer et al., 2020; Hew, 2016; Huang et al., 2019), we found that students' perceptions of relatedness satisfaction help enhance their behavioural participation in the online learning activities and triggered their task-facilitating emotions towards teachers, peers and learning activities.

However, the findings also highlighted the ‘sophisticated’ nature of relatedness satisfaction, which can engender different effects on various forms of student engagement and academic achievement in different contexts. One possible explanation is that there exist cross-cultural differences concerning the specific relations between relatedness satisfaction and cognitive engagement, and when relatedness is not satisfied in a context that places high value on education, the feeling of isolation can motivate students to think deeply and exert necessary efforts to comprehend complex ideas or master difficult skills. Similarly, this study did not find significant effect of relatedness satisfaction on students’ academic achievement. To sum up, this study confirms the positive impacts of students’ perceptions of competence and autonomy satisfaction on their engagement and academic achievement in the context of emergency online learning. This supports SDT’s proposition that online learning environments that satisfy learners’ psychological needs can promote more optimal motivation, resulting in positive engagement and outcomes (e.g. Deci & Ryan, 2000, 2008; Huang et al., 2019; Reeve, 2012).

Second, this study contributes to existing literature by examining the effects of student engagement within SDT. In line with previous studies (e.g. Butz & Stupnisky, 2016; Hsu et al., 2019; Sun et al., 2019), the results reported that student engagement acted as partial or full mediators between psychological needs satisfaction and academic achievement. Specifically, the effects of autonomy and competence satisfaction on students’ academic achievement were partially mediated by the extent to which they cognitively, emotionally and behaviourally engaged in online learning activities. The feelings of autonomy and competence fulfilled in the online environment incited the behavioural, cognitive and emotional aspects of students’ active involvement in online learning activities, which in turn contributed to their improved academic achievement (Hsu et al., 2019; Kahu, 2013).

Student engagement results from complicated interactions between individuals and certain contexts; it is often difficult for teachers to engage students in learning activities during an emergency crisis by ‘just teaching online’ (Hodges et al., 2020). Our research findings substantiate the argument that pathways to student engagement may stem from the contexts supporting students’ experiences of volition, self-endorsement and free will as they initiate, maintain and regulate learning activities online; furthermore, these can enhance students’ feelings of being competent, efficacious and capable of completing challenging learning tasks and achieving desired outcomes (Butz & Stupnisky, 2016; Ferrer et al., 2020). Our study also provides empirical evidence of the fulfillment of psychological needs of autonomy and competence as pathways to improving students’ academic achievement, which is the most important concern of online learning under the pandemic situation (Besser et al., 2020; Hodges et al., 2020).

Furthermore, the current study revealed that the effect of relatedness satisfaction on students’ academic achievement was completely mediated by the extent to which they emotionally and behaviourally engaged in online learning activities. In other words, the total effect of relatedness satisfaction on students’ academic achievement is transmitted through mediators of emotional and behavioural engagement, thus highlighting the important roles of both forms of engagement in an emergency online learning environment. In addition, the significant negative correlation between relatedness satisfaction and cognitive engagement cancelled out the significant positive correlation between cognitive engagement and academic achievement, resulting in the absence of a statistically significant mediating effect of relatedness satisfaction on students’ academic achievement in this study. This finding calls for more nuanced empirical studies to validate the unexpected link between relatedness satisfaction and cognitive engagement found in our study.

Third, researchers have suggested that first-generation and non-first-generation students may have different perceptions of psychological needs satisfaction, thereby resulting in different levels of student engagement and academic achievement. Surprisingly, the current study revealed a different picture: the emergency situation did not lead to different consequences between first-generation and non-first-generation students in terms of the effects of psychological needs satisfaction on their engagement and academic achievement in the online learning context. The probability of such invariance may result from the concerted efforts made by the Chinese government and universities to provide strong resource guarantees and technical support for emergency online teaching during the pandemic (Wu & Li, 2020). Such efforts ultimately minimised the technological gap between first-generation and non-first-generation students. Another explanation may lie in the fact that postgraduate students are essentially highly autonomous and independent. They have higher levels of metacognitive functioning and critical thinking strategies to overcome the disadvantageous situation caused by the digital divide compared to students at the K-12 level and to undergraduate students who have been found in prior studies to be significantly affected by the digital divide (Butz & Stupnisky, 2016). However, more empirical research may be needed to test the results amongst diverse student populations and within different social contexts.

Limitations and implications

Despite the noticeable contributions mentioned above, we should be aware of the limitations of this study. First, this study involved a large-scale sample located in an important metropolis of China. Hence, more samples from other contexts may be needed in future studies to extend the generalisability of our findings. Second, students' motivation, engagement and academic achievement have changed over time; however, this study used cross-sectional data to examine their relationships, failing to demonstrate evidence of causality. Hence, future studies are needed to conduct experiments or longitudinal studies to explore more sophisticated evidence regarding this topic. Third, this study followed Reeve's (2012) notion, which equated motivation with psychological needs satisfaction from the psychological needs-based framework with SDT. In relation to this, future studies could directly measure students' motivation (e.g. extrinsic and intrinsic motivation) anchored in the continuum of SDT, as doing so might yield different results about their relationships. Fourth, it might be helpful for future studies to measure the variable of cultural context to deepen our understanding of the cultural configurations with SDT. Lastly, this study measured students' academic achievement via the method of self-assessment, future studies are welcome to use students' GPA as the proxy variable of academic achievement.

Despite these limitations, the practical implications of this study arise from the findings within the emergency online learning context, which emphasises the critical importance of creating a need-supportive online learning environment. Previous research has identified the fundamental differences between online and conventional offline courses and challenges for instructors to support psychological needs-based motivation were even greater in the case of emergency online migration (Fryer & Bovee, 2016). Given the fact that the devastating consequences of COVID-19 persist, the current study reminds us of the significance of efforts aimed at creating a favourable online environment to satisfy students' psychological needs. It is not just about making the courses available online; rather, instructors

must anticipate the difficulties of student online learning and make conscientious efforts to enhance student motivation and engagement during the process of course planning.

With the theoretical rationales of SDT in mind, instructors are assumed to play an important role in motivating students by demonstrating support of autonomy, competence and relatedness and need-supportive teaching practices are accordingly grouped into dimensions of autonomy support (autonomy), structure (competence) and involvement (relatedness) (Fryer & Bovee, 2021; Leenknecht et al., 2017). Need-supportive teaching is a powerful instrument for teachers to satisfy students' psychological needs of autonomy, competence, and relatedness in order to increase their motivation, engagement and academic achievement (Dupont et al., 2014; Fryer & Bovee, 2021; Leenknecht et al., 2017). First, students' need of autonomy can be promoted by being autonomy supportive in online teaching. The need of autonomy can be supported through using several teaching strategies, such as providing rationales for requested online learning tasks, communicating with students the learning goals and contents, allowing students to work independently at their own pace, understanding students' maladaptive behaviors in the emergency case and avoiding putting undue pressure on students (Leenknecht et al., 2017). Second, students' perceptions of competence satisfaction can be enhanced by being competence supportive in online teaching. The need of competence can be supported through using several teaching strategies, such as providing structure to keep students on tasks, communicating expectations clearly, providing explicit guidelines and progress-enabling scaffolding and avoiding chaos during the emergency transition (Leenknecht et al., 2017). Third, the role of relatedness depends on the nature of the students and study programs, and in most cases, it is necessary for instructors to provide relatedness support in online teaching for students. Teachers can promote students' feelings of relatedness satisfaction by showing affection, expressing understanding, providing opportunities of group work and making sure to help students in a timely manner.

Declarations

Conflict of interest The authors declare no competing interests.

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