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ORIGINAL RESEARCH

Student Engagement in the HyFlex and Online Classrooms: Lessons from the COVID-19 Pandemic

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Abstract
Student engagement is determined by the degree to which students perceive that their psychological needs for autonomy, competence, and relatedness are met as prescribed. The COVID-19 pandemic, with its sudden and dramatic shift to mandatory HyFlex (alternating online and face-to-face student attendance) or online learning only, meant less or no face-to-face interactions with peers and faculty, which had an impact on student motivation and engagement in the classroom, as reflected in the National Survey of Student Engagement. This new educational landscape will likely remain in effect to a certain extent, and, thus, there is a need for a deeper understanding of its impact on students' basic psychological needs and ultimately their engagement in the classroom. Building on self-determination theory and self-system processes, we studied 329 student responses to a survey conducted at a private Northeastern university in the United States and analyzed. We found that the impact of need for autonomy on student engagement is mediated by need for competence, and need for relatedness is directly impacting student engagement. Theoretical and practical implications are discussed in detail.

Keywords Self-determination theory · Self-system · Student engagement

1 Introduction

The use of information communication technologies (ICT) has brought changes in virtually every industry. The interest for harnessing the potential of ICT in teaching and learning has gained prominence in the last several years, especially in the higher education (Comi et al., 2017). Benefits of ICT in education have been studied extensively and positive effects on

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educational achievements are concluded in a myriad of studies, for example, Falck et al. (2018) and Comi et al. (2017). Studies in favor of positive effect of ICT list reasons such as better access to information and resources for learning, enables individualized instructions and better monitor student progress with targeted intervention (Falck et al., 2018). Furthermore, ICT in education provides greater flexibility and autonomy to students while also improve their experiences (De Witte & Rogge, 2014). ICT also enables the teachers to provide more complete, interesting, and interactive lessons and also found to reduce the educational costs in the long run (Comi et al., 2017).

On the other hand, arguments against ICT in education list reasons such as distraction from focused learning and undermines the teacher–student relationship (De Witte & Rogge, 2014; Falck et al., 2018). Capabilities of schools to adapt the teaching methods and technology self-efficacy of teachers and students are also drive the realization of ICT benefits in education (Spiezia, 2010). Falck et al. (2018) argue that some subjects and activities are better suited for traditional face-to-face learning methods while others are better suited for ICT-based education. Similarly, Fernández-Gutiérrez et al. (2020) pointed out that the impact of ICT on educational outcome depends on the subject and on the manner in which technology is utilized. While we have a good understanding of the impact of ICT on learning outcome and academic achievements, the contextual impact on student engagement requires further scrutiny.

Student engagement is defined as student involvement in educationally purposeful activities (Kuh, 2001) and the time an energy that students purposefully dedicate to learning activities (Kuh, 2003). It is found to be the strongest predictor and a critical factor for academic achievement (Astin, 1984; Kuh, 2008; Lei et al., 2018; Svanum & Bigatti, 2009) and personal development (Handelsmanet al., 2005). Dumford and Miller (2018) found that higher education students with greater number of online courses reported less exposure to effective teaching practices and lower quality of interactions. Students were less likely to engage in collaborative learning, student-faculty interactions, and discussion with peers. These studies were based on online courses that were designed to deliver content to students who were prepared to learn remotely and chose such course delivery modality voluntarily. The impact of nonvoluntary shift to online learning on student engagement is still not well understood in the extant literature (Paulsen & McCormick, 2020; Salas-Pilco et al., 2022). This study aims to fill this gap by scrutinizing the impact of the COVID-19 pandemic on student's engagement.

As noted in the National Survey of Student Engagement (NSSE), the COVID-19 pandemic has shifted the ways in which students engage, as seen in four areas: (1) challenges with academic content, (2) learning with peers, (3) experiences with faculty, and (4) connection to a campus environment (Education, 2021). With the sudden impact on education caused by the pandemic and the transition to HyFlex (alternating online and face-to-face student attendance) and online learning as the only option during the lockdown period of the pandemic, there is a need to understand the underlying mechanisms of the change in student engagement. In order to do so, we approach student engagement from the basic psychological needs, namely need for autonomy, need for relatedness, and need for competence as the basic tenets of intrinsic motivation (Ryan & Deci, 2017). According to Niemiec and Ryan (2009), the satisfaction of these needs is the most crucial factor that provides what is necessary for stimulating student engagement in the classroom.

Additional research is, therefore, needed to understand the student engagement in the nonvoluntary HyFlex and online environment. We review and draw the relationship between the dimensions of student engagement and the basic psychological needs. Thus, the study is guided by the following two research objectives:

1. understanding the impact of student's basic psychological needs on student engagement during the nonvoluntary shift to HyFlex and online learning methods and
2. understanding the pedagogical implications of the shifting social and academic context.

Addressing these objectives will help professionals and academics in the field of digital education across the world by better understanding the changing nature of student engagement and identify ways to remedy the emerging unique challenges. The potential to nonvoluntary shifting to partial or full online class delivery is here to stay and our study aims to provide guidance to innovative and proactive pedagogy to improve student engagement and thus academic achievements and personal development.

To begin to address these research questions, we begin with a review of the student engagement literature that forms the theoretical and pedagogical foundations of our conceptual model and hypotheses. This is followed by introducing the conceptual foundations and the theoretical argument for the proposed conceptual model. Next, we present the procedures of testing the proposed model empirically and describe the results based on 329 responses. Finally, we provide a discussion of the findings in light of pedagogical and theoretical contributions, followed by limitations of the study, and areas for future research.

2 Literature Review

2.1 Student Engagement

Student engagement theory dates back to the 1980s with the advent of the psychological process approach, which concerns how students exert physical and psychological energy in their academic experiences. The study of student engagement began with research on the impact of time and effort spent on education (Dewey, 1897) and the psychological study of the self (Baldwin, 1987). Recognizing and measuring engagement level provided challenges and several models were tested in the early literature. Astin (1984) proposed antecedents to engagement, such as time spent on campus, energy devoted to studying, participation in student organizations, and frequent interactions with faculty and other students. Researchers have identified other mechanisms in the over 20 years since Astin's seminal work:

- Teacher–student interaction (Hoffman, 1996)
- Identification with school and participation in school activities (Leithwood & Jantzi, 1999)
- Active investment in learning (Fredricks et al., 2004)
- Persistence in academic work and emotional attachment (Law, 2007)
- Collaborative learning, academic challenge, and student-faculty interaction (Robinson & Hullinger, 2008)

Organizational characteristics also are relevant to student engagement and include school climate and commitment to campus (Astin, 1984; Pike & Kuh, 2005), institutional policies and mission (Kezar & Kinzie, 2006), and racial diversity (Denson & Chang, 2009; Kuh, 2008). In addition, personal attributes, such as gender and parents' education level (Fullarton, 2002), as well as emotional intelligence and self-efficacy (Bandura, 1977; Duran et al., 2006) influence student engagement.

Student engagement in recent literature is synonymous with academic engagement and commitment as well as student and coursework involvement. The most prominent engagement model was described by Fredricks et al. (2004) and the authors regarded to it as a multi-faceted complex construct that includes three distinct but interrelated dimensions:

1. behavioral engagement, it is expressed as explicit and observable behaviors and defined in terms of participation, interaction, collaboration, achievement, persistence, performance, skill development, and learning activity completion in social and extracurricular activities.
2. emotional engagement, the emotional response and reactions to the learning environment, learning activities, attitude toward teachers, peers, and courses; value for learning circumstances, feelings of well-being that affect the ties to the school and willingness to do the required work.
3. cognitive engagement, the willingness to invest effort to learn difficult concepts, willingness to learn, self-efficacy, perceived ability, critical thinking, ability to learn complex ideas and skills.

The antecedents of these dimensions include opportunities in school for participation and interpersonal relationships. Student engagement is considered malleable through interaction and responsiveness to variations in the environment and context (Connell, 1990; Finn & Rock, 1997). The non-voluntary shift to online education, the environmental and contextual changes undermine these findings and yet to be explored.

Reeve and Tseng (2011) suggested adding a fourth dimension, namely agentic engagement, which highlights the proactive and intentional activity of student to personalize the conditions of learning. This agentic effort highlights student's role as a coordinator of their own studies to achieve personal interests and goals. This engagement is manifested through asking questions, seeking clarifications, expressing preferences, offering a suggestion or contribution, communicating likes and dislikes.

2.2 Student Engagement in Online Learning

Student engagement is traditionally associated with face-to-face classroom learning, but recent studies explored this course delivery modality (Dumford et al., 2018; Lei et al., 2018). However, this trend has been disrupted by the COVID-19 pandemic when online learning has been the prominent delivery model. Teachers moved their lessons to an online platform without prior training and preparation while reaching students remotely. Recent studies have investigated this phenomenon as "emergency remote learning" (Abou-Khalil et al., 2021; Kovačević et al., 2021). The benefits of traditional online learning, such as flexibility of time, place, and pace, technology mediated collaboration were more challenging to realize in the emergency remote learning context (Chiu, 2022; Salas-Pilco et al., 2022). Fredericks et al.'s (2004) model can be applied to the student engagement in the online learning context through ICT capabilities such as (1) behavioral engagement: students actively participate in an online class; (2) cognitive engagement: online students show motivation to learn in an online class and demonstrate self-regulated learning; and (3) emotional engagement: students express positive attitudes and maintain the relationship with teachers to create a positive online learning environment.

2.3 Self-determination Theory: Basic Psychological Needs

Self-determination theory (SDT) asserts that all students have three inherent, basic psychological needs that must be met to foster well-being and enable their self-initiated behavior or motivations. Namely, need for autonomy (to regulate themselves, freedom for choices), competence (to interact effectively with the learning environment and conquer challenging activities), relatedness (to feel connected with their teacher, peers, build and maintain friendly relationships, provide and receive support). These inherent needs need to be fulfilled in order for the students to experience academic satisfaction, persistence, and feel engaged in the classroom (Niemiec & Ryan, 2009; Ryan & Deci, 2017). In addition to self-determination theory (Chiu, 2021; Liu et al., 2019), student motivation and engagement have been studied in the context of the following other theories: flow (Hamari et al., 2016), campus-class-technology (Günüç & Kuzu, 2015), self-regulation and social cognitive learning (Pellas, 2014), motivation (Verhagen et al., 2012). The way student engagement is affected by contextual change, however, has not been explored. Educators have assumed that the three psychological needs are satisfied in a stable social context, driving student motivation and manifesting in student engagement in the classroom (Ryan & Deci, 2017; Standage et al., 2005).

As noted, however, the COVID-19 pandemic forced a shift from traditional face-to-face instruction to HyFlex or online-only course delivery, which has had a negative impact on students' sense of relatedness, i.e., peer interaction and campus involvement (Holzer et al., 2021) and its impact on students' motivation is still unclear (Ryan & Deci, 2020). To address this gap in the research, we investigated the mechanisms that contribute to individual student engagement. In particular, we studied the impact on psychological needs on student engagement in response to disruptions in the social context of learning.

2.4 Basic Psychological Needs and Student Engagement

Reeve (2012) posits that meeting the basic psychological needs is a significant antecedent and highly relevant to academic engagement. The relationship between the psychological needs and engagement is described by Reeve et al. (2019) as (Table 1):

Meeting these basic needs leads students to have a sense of energy, enjoyment, which leads to high-quality engagement and the ability to cope with challenges associated with academic growth (Ryan & Deci, 2017). Other recent empirical studies in the higher education context highlight the relevance of satisfied basic psychological needs to student engagement (Benlahcene et al., 2020; Nunez & Leon, 2019). Molinari and Mameli (2018) extended the three basic psychological needs with need for justice and suggested that the inclusion of this construct in school settings should be viewed as an essential requirement,

Table 1 Psychological needs and engagement

Basic psychological needs	Student engagement	Outcome if need is met
Need for autonomy	Behavioral engagement	Pay more attention, follow through
Need for relatedness	Emotional engagement	Feel interested, connected
Need for competence	Cognitive engagement	Use learning strategies, confidence
	Agentic engagement	Reflect on learning, discuss

as it promotes innate student motivation and active involvement. There is a scarce of studies that consider the impact of the basic psychological needs on student engagement in the nonvoluntary online context and this study aims to fill this gap.

3 Conceptual Foundation

After reviewing the dimensions of student engagement and the related basic psychological needs from the SDT, we position student engagement in a larger motivational paradigm. SDT describes the nature of engagement from dynamic to self-processes where people share the basic psychological needs. If these needs are met by interacting with others in their social context, students are more likely will be engaged in relevant activities. Meeting the needs for competence, autonomy, and connectedness enables students to become self-determined in reaching their goals. Student's psychological needs can be influenced by teacher–student relationship, their self-efficacy, and their persistence to complete activities (Reeve, 2013; Ryan & Deci, 2016). However, a deeper understanding of how the changed social context caused by the COVID-19 pandemic is impacting the extent the basic psychological needs are met and their impact on student engagement is prompted. To address this, the present study aims to understand the complex relationship between self-perceptions (need satisfactions) and engagement in the non-voluntary HyFlex and online learning environment.

The theoretical guide for how the social system in the classroom impacts students' motivational experiences is well understood through the lens of SDT (Ryan & Deci, 2017), however, it does not provide a clear understanding of the role of the engagement within students' motivational system. Based on multiple motivation models and theories, Skinner et al. (2008, 2009) developed the self-system model of motivational development (SSMMD), which helped to better connect classroom engagement to other variables of human motivation from theories, such SDT.

Fredricks et al. (2004) note that contextual changes are likely to have an impact on engagement due to the interconnectedness and interdependence of the environment/context and action (student engagement) mediated by the self-variables. Overall, the changes in the social context and classroom structure have been found to have an impact on student support and motivation (Picton et al., 2018). The social context change during the COVID-19 pandemic inevitably impacted student's motivation and, in turn, their engagement in the HyFlex or online classroom. In this section we describe how we conceptualize the basic psychological needs as antecedents of student engagement. This integrated model includes four types of variables related to motivations:

1. Context variables—refers to students' social environment, including parents, teachers, and peers. Students evaluate their role and status through a reflective appraisal of the social context of their learning environment. They observe the context in which they exist and give meaning to the various activities and interpret their own experiences.
2. Self-related variables—learners' beliefs about abilities, attitudes, values, which collectively influence students' perceptions of how well their basic psychological needs are met. Students set goals and rely on their basic psychological needs to be met in order to find the motivation to achieve these goals. Meeting the basic psychological needs through motivational mechanisms drives self-system development (Connell & Wellborn, 1991; Ryan & Deci, 2017, 2020) and gives rise to engagement in the classroom.

3. Action variables—goal-directed behaviors, such as engagement in a learning activity.
4. Outcome variables—learning outcome, cognitive development and learning.

The four components of SSMMD highlights the process in which the basic psychological needs of SDT are affected by the context and affect the engagement and relevant learning outcomes.

We focus on the interconnected triad of meta-levels of (1) context, or social; (2) self, or psychological needs; and (3) action, or engagement. Variability in the system occurs as a result of changes in the context of learning, which has an impact on the actions (i.e., engagement) (Connell, 1990). An action, however, is dependent on the extent to which psychological needs are met (i.e., psychological needs as a mediator). Figure 1 displays the relationship of these above discussed meta-levels of the model, which we adapted as a guiding holistic model of the motivational process in the HyFelx and online learning. Please note that the outcome is out of the scope of this study.

In order to better understand the self-related variables, we developed related measures that reflect the psychological need. The need for connectedness is measured through student–teacher relationship as it is related to the behavioral engagement focusing on attitude toward peers, teachers, courses and ties to the school (García-Moya et al., 2021). The need for competence is measured through learning confidence as it is related to the cognitive engagement dimension that includes the ability to learn difficult concepts and perceived self-efficacy (Bandura, 1997; Zimmermann & Bandura, 1994). The need for autonomy is measured through grit as it reflects the persistence it takes to accomplish a task and master skills as described in the related behavioral engagement dimension (Hernández et al., 2020). We chose these measures as they are closely reflecting the aspects of engagement in Reeve and Tseng (2011) items. We also included the agentic engagement in the emotional engagement dimension as the measurement items are closely related and Eccles (2016) calls for more research to determine whether agentic engagement predicts engagement outcome differently than the established other three dimensions. Engagement studies mainly use the three dimensions yet the four-dimension models start to gain attention in recent research.

In the next sections we establish the theoretical arguments of the relationships among the self-variables and the action-variable, which then we empirically investigate.

4 Hypothesis Development

The review of relevant literature and theories suggest that self-system processes are useful in predicting student engagement. In the following section, we provide our theoretical arguments followed by the proposed hypotheses.

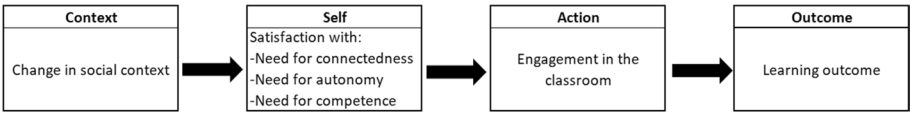

Fig. 1 Meta-components of student engagement in the Hyflex or online classroom

4.1 Need for Autonomy (Grit)

Students connect their actions with their goals through intrinsic motivation. In this study, we define the need for autonomy as goal-oriented students' intrinsic motivation to reach their academic goals through perseverance and passion, driven by personal choice (Malureanu et al., 2021). This conceptual framework aligns with that of Deci and Ryan (2000), whereby students have the need to be in control of their behaviors and goals. Performing a task in a persistent manner with patience and enthusiasm, thus meeting long-term goals, enhances a student's competence in the classroom (Duckworth et al., 2007; Kuh et al., 2008; Law, 2007). To meet long-term goals, determined and motivated students are known to have grit, which is considered a strong indicator of students' confidence in their ability to learn and engagement in the classroom (Duckworth et al., 2007; Lam & Zhou, 2019).

Self-efficacy has been found to affect effort, persistence, resilience, confidence, and achievement of predetermined goals (Bandura, 1997). Self-regulated behaviors, such as being determined and following through on tasks with perseverance, play a vital role in HyFlex or online learning only (Antonio, 2007; Joo et al., 2000) and are positively related to student engagement (Wong et al., 2021a, 2021b). Prior studies have shown that individualized, autonomous learning environments create optimal conditions for learners to perceive their abilities as competent (Niemiec & Ryan, 2009). SDT suggests that both grit (need for autonomy) and learning confidence (need for competence) are SDT (Self-Determination Theory) suggests that both autonomy and competence are essential prerequisites for fostering intrinsic motivation (Ryan & Deci, 2017). Similarly, grit has a positive impact on self-efficacy and confidence in achieving goals using e-learning platforms (Malureanu et al., 2021). Therefore, our first two hypotheses are as follows:

Hypothesis 1 A greater level of grit will have a positive impact on student engagement in the HyFlex or online classroom.

Hypothesis 2 A greater level of grit will have a positive impact on learning confidence in the HyFlex or online classroom.

4.2 Need for Competence (Learning Confidence)

Wolters and Hussain (2015) found that self-regulated learning, which includes self-efficacy as a perceived judgment about one's capabilities and competency, is a mediator between grit and academic achievement. In the same vein, we investigate whether learning competence mediates the relationship between grit and student engagement when the social context changes. Competence is defined as students' need to gain skills and experience as well as the ability to express their talents and skills (Ryan & Deci, 2017). In the HyFlex or online learning-only environments, students' confidence in their competence is challenged when they feel isolated from their peers and instructors (Bollinger & Martindale, 2004; Heilporn & Lakhal, 2021). The lack of opportunities for conformity with peers can decrease students' confidence in their skills (Conley et al., 2018). Satisfying the need for competence has a positive impact on motivation (Jang et al., 2009a, 2009b) and academic engagement (Jang et al., 2016). Students who report high confidence in their learning in a HyFlex or online learning environment are more likely to satisfy their need for competence and successfully engage in the learning process (Sergis et al., 2018). Therefore, we posit:

Hypothesis 3 A greater level of learning confidence will have a positive impact on student engagement in the classroom.

4.3 Need for Relatedness (Student–Teacher Relationships)

In addition to autonomy and competence, decades of research demonstrate that students demand relatedness and support from their parents (Steinberg et al., 1995), teachers (Stipek, 2002), and peers (Hymel et al., 1996). A sense of relatedness functions as a source of motivation for students, especially in times of difficulty. Relatedness, as a self-system factor of student engagement, has shown positive impacts, in general (Anderman & Anderman, 1999), and on creative problem-solving, specifically (Bozan, 2017).

For the purpose of this study, we focused on the effects of teacher–student relationships as a motivational component, as this relationship became the primary link to school in HyFlex or online learning-only environments and faced unique challenges. In this study, we define the student–teacher relationship as educators' fostering student confidence and motivation, with the ultimate goal as positive learning outcomes. Several studies have found that engagement is more likely to develop when the student–teacher relationship is strong (Ryan et al., 1994; Zhang & Aasheim, 2011) and students perceive teachers as supportive (Leese, 2009) and knowledgeable (Zhu, 2006). Therefore, we posit:

Hypothesis 4 A strong student–teacher relationship will increase student engagement in the classroom.

4.4 Grading Fairness as a Moderator

During the COVID-19 pandemic, it was common to offer pass/fail grades, and, where letter grades were given, reports of inflated grades were common. Some students, however, perceived that their work was not recognized and that they were given grades that did not reflect their knowledge and effort (Retta, 2020; Watanabe, 2020). The perceived fairness of grades can have an impact on student–teacher relationships and student engagement (Schwartz, 2019). Hence, we posit:

Hypothesis 5 The connection between student–teacher relationship and student engagement in the classroom is moderated by student perceptions of grading fairness.

In our conceptual model, displayed in Fig. 2, the self-system processes encompass the student's motivation to grow through the three innate universal psychological needs.

5 Methods

5.1 Sample and Procedure

We applied quantitative method by distributing a self-administered questionnaire to collect the primary data to empirically test the proposed hypotheses. We employed convenience sampling method in the lead authors' university after the Institutional Review Board approved the questionnaire, with exemption, in November 2020. Convenience sampling is

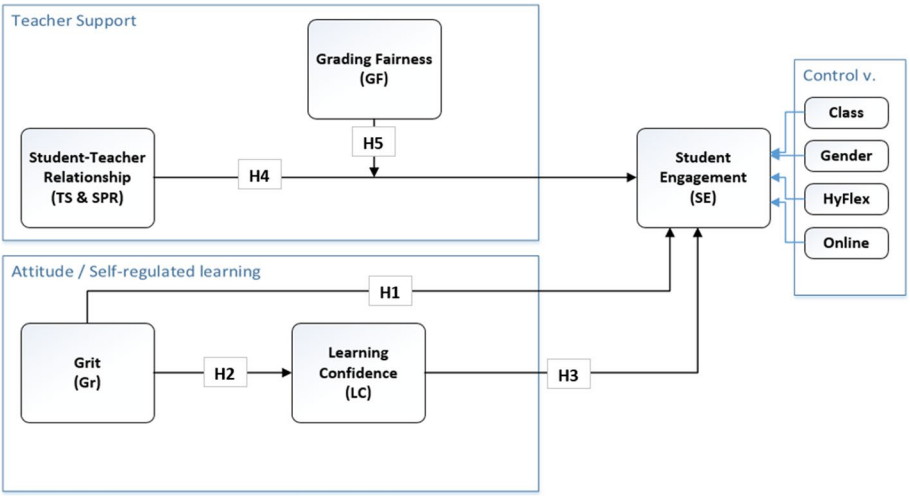

Fig. 2 Conceptual model for student engagement in the Hyflex or online-only classroom

a non-probability sampling technique we utilized as the target group for the purposes of this study was available with easy access. Participants were 367 undergraduate students enrolled in a variety of majors across multiple colleges at a private Northeastern university in the United States. Participation was voluntary, and informed consent was provided. All students indicated that they had taken at least one semester of HyFlex or online classes. After removing cases with excessive missing data, we had a usable sample of 329 responses, which included responses from 173 male students, 155 female students, and one student with an undisclosed gender. There were 153 freshmen, 84 sophomores, 35 juniors, and 57 seniors. Age ranged from 18 to 22 years (M = 19.32, SD = 1.26).

5.2 Measures

The survey was administered online, using Qualtrics, and required to accept the consent. The first section of the survey requested demographic and academic information, self-reported GPA, and the number of semesters that students took HyFlex or online learning-only classes, which were used as control variables. The next section collected responses on measurement items related to the self-variables (student–teacher relationship, learning confidence, and grit) and the dependent variable of student engagement. We also collected responses on students' perceived grading fairness to measure its proposed moderating effect on the relationship between student–teacher relationship and student engagement. The items were statements to which respondents needed to indicate their level of agreement or indicate the extent the statement described them. Each self-process related constructs were measured with at least five items on a Likert Scale. Student Engagement related measurement items asked students to rate their confidence level that they are able to, for example, "ask the instructor questions about the material they are presenting". Answers range from 1—not confident at all to 5—very confident (M = 3.44, SD = 1.37). Grit related measurement items asked student to rate statements with regard to how much it describes them, for example, "I often set goals but later choose to pursue a different one. Answers range from 1—not like me at all to 5—very much like me (M = 2.95, SD = 1.09). Student–teacher

relationship related measurement items asked students to rate the extent they agree with statements such as, "I feel comfortable asking questions my professor questions in class". Answers range from 1—strongly disagree to 7—strongly agree (M = 5.50, SD = 1.32). Learning confidence related measurement items asked students to rate the extent they agree with statements such as, "I am well versed using the Internet to find suitable learning resources when I feel stuck during my studies.". Answers range from 1—strongly disagree to 7—strongly agree (M = 3.52, SD = 1.72). Grading fairness related measurement items asked students to rate the extent they agree with statements such as, "I believe my GPA reflects my knowledge in mu classes". Answers range from 1—strongly disagree to 7—strongly agree (M = 3.28, SD = 1.38). The instruments' internal consistency was validated analyzed using Cronbach's alpha and the scales scores were above 0.70, which indicates reliable measures (Hair et al., 2010). The full set of measures and the literature they were cited from can be found in "Appendix 2".

5.3 Data Analysis

5.3.1 Data Preparation

We had complete data for all measures except Grading Fairness (GF), which included GPA and how well the student's performance reflected his or her knowledge and effort. The amount of missing data was less than 4.0% for any given variable. Therefore, we imputed missing values with the median for ordinal variables (GF_2–5) and with the mean for continuous variables (GF_1) (Hair et al., 2010). The univariate normality of these variables was acceptable, with most skewness and kurtosis values as falling between ± 1. The statistics can be found in "Appendix 1", where exceptions are in italics. The most extreme value was 2.504 for kurtosis on student–teacher relationship (STR) which was still below acceptable thresholds (Hair et al., 2010). Therefore, our data were sufficiently complete and normal to proceed with additional analyses.

5.3.2 Measurement Validation

Using confirmatory factor analysis (CFA), we sought to validate our latent factors. As part of this process, we needed to delete some measures that fatally undermined the validity measure of the construct. In many cases, these requisite omissions were unsurprising due to the use of many reverse-coded questions (Hughes, 2009) and some unevenly distributed multidimensional measures (e.g., three items measured one aspect, but only one item measured other aspects). In retrospect, we also recognize that some measures were sufficiently ambiguous or complex as to result in an inconsistent understanding by participants (resulting in poor correlations with other measures). With this in mind, we reduced our factors to clearly measure only single reflective dimensions to ensure that we were validly measuring what we intended to measure. For some factors (Learning Confidence [LC] and GF), this resulted in heavy trimming, which we recognize as a limitation (see "Appendix 2" for details). As shown in Table 2 and by reading the measures' wording in the Appendix 2, however, it is clear that our resulting factors measure the intended constructs in a valid manner.

With regards to discriminant validity, the square root of the average variance extracted (AVE; on the diagonal) for each factor was greater than any correlation with another factor (Fornell & Larcker, 1981). We also checked the heterotrait–monotrait ratios and found that

Table 2 Validity analysis

Factor	CR	AVE	GR	SE	STR	LC	GF
Grit (GR)	0.727	0.400	0.633				
Student engagement (SE)	0.805	0.514	−0.341***	0.717			
Student–teacher relationship (STR)	0.900	0.532	−0.175**	0.496***	0.729		
Learning confidence (LC)	0.694	0.545	0.504***	−0.486***	−0.318***	0.738	
Grading fairness (GF)	0.788	0.651	−0.261***	0.429***	0.367***	−0.309***	0.807

** significant on the P<0.01 level; ***significant on the P<0.001 level

all were less than the recommended conservative threshold of 0.850 (Hensler et al., 2015). For convergent validity, the AVE was greater than 0.500 in all cases except for Grit (GR), which was entirely reverse-coded except for GR_5. Thus, a lower AVE was not unexpected (Hair et al., 2010). Nevertheless, the composite reliability (CR) was above the recommended target of 0.70 for that factor, indicating probable convergence (Malhorta et al., 2006). With regard to factor reliability, the CR for all factors was above the recommended target of 0.70, except for LC, which came very close to the target; in addition, LC had only two remaining indicators, which suggested some leniency in reliability scores (Hair et al., 2010).

5.3.3 Measurement Model Fit

After testing validity, we assessed model fit on the final measurement model. We observed adequate fit (Hu & Bentler, 1999), as demonstrated by the values in Table 3.

5.3.4 Method Bias

Because our data, including the independent variables, dependent variable, and mediating and moderating variables, were collected from a single source, we also tested common method bias (CMB). While we implemented procedural strategies to reduce CMB, we did not collect a theoretically driven marker variable for a specific source of bias; therefore, we tested method bias using the unmeasured latent factor (ULF) approach (Podsakoff et al., 2012) as it is a better fit than the independent variable or confirmatory factor analysis marker technique or Hartman's one factor test as described by Jordan and Troth (2020). Undesirable effects from a ULF (such as extracting trait variance in addition to method variance) are minimized when all measures from all latent factors from the dataset

Table 3 Measurement model fit

Measure	Estimate	Target
CMIN	369.420	–
DF	160.000	–
CMIN/DF	2.309	Between 1 and 3
CFI	0.921	> 0.95
SRMR	0.061	< 0.08
RMSEA	0.063	< 0.06

are included in the CMB test, whether or not they are used in the final model (Mackenize & Podsakoff, 2012). With all measures added back into the model, the model with the ULF did not fit the data as well as the model without the ULF (CFI = 0.780, ΔCFI = 0.141). Comparing our unconstrained ULF model to the model with paths from the ULF constrained to zero (implying zero shared variance), the results of a chi-square difference test indicated that the amount of shared variance across all measured items was not zero ($p < 0.05$). To estimate the amount of shared variance, we constrained all paths from the ULF as equal. The square of the unstandardized regression weight indicates 21.9% of the variance shared across all measures. This was far less than the target of 50% (Podsakoff, 2003), indicating that, although the measures do share significant variance, it is unlikely that method variance biases our estimates (Mackenize & Podsakoff, 2012). Therefore, we returned to our final model (without ULF and extra measures) to proceed with structural analyses, using imputed factor scores. We used factor scores to simplify the model for interaction testing.

6 Results of the Structural Modeling

We used AMOS to test our structural model (Arbuckle, 2019). The path model included all theorized constructs as factor scores; the moderator GF and the product term of STR with GF (STR x GF) was used to test for moderation. We also used prudent control variables (class, gender, HyFlex experience, and online learning-only experience). Controls were theorized to affect only the dependent variable (student engagement [SE]). The path analysis revealed the fit and quality of the model and the R^2-values. This analysis helped to explain how GR, LC, and STR contribute to SE.

The model fit the data fairly well, with a CFI of 0.979 and an SRMR of 0.062. The variance explained in the endogenous variables was adequate, with 37.0% for LC and 49.0% for SE. Table 4 presents the standardized regression weights, effect sizes, and a summary of the hypothesis tests. Effects of adequate size were observed for all supported hypotheses. A

Table 4 Standardized regression weights

Predictor	Outcome	Std. beta	Effect size	Hypothesis	Supported/unsupported
GR	Student engag	−0.095	0.024 (Small)	H1	Unsupported
GR	Learning conf	0.606***	0.581 (Large)	H2	Supported
LC	Student engag	0.341***	0.047 (Small)	H3	Supported
STR	Student engag	0.466***	0.046 (Small)	H4	Supported
GF	Student engag	0.518*	0.018 (None)	H5	Unsupported
STR × GF	Student engag	−0.396	0.007 (None)		
Control variable					
Class	Student engag	−0.083†	0.010 (None)		
Gender	Student engag	0.099*	0.022 (Small)		
HyFlex length	Student engag	0.001†	0.000 (None)		
Online length	Student engag	−0.065	0.003 (None)		

Student engag. student engagement, *Learning conf.* learning confidence

†$p < 0.10$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

post-hoc power analysis provided evidence that we had sufficient statistical power (> 0.80) to detect observable effects.

GR was found to be a significant predictor of LC ($\beta = 0.606$, $p < 0.001$, effect size = 0.581 [effect size]). Similarly, LC was a significant predictor of SE ($\beta = 0.341$, $p < 0.001$, effect size = 0.047). The direct impact of GR on SE was found to be non-significant ($p > 0.10$) in the presence of LC as a mediator. This indicates that LC has a full mediating effect on GR and SE. Even though the literature does not require a direct path to be tested, we note that GR's path coefficient in the absence of LC ($\beta = 0.255$, $p < 0.001$) confirms our finding of LC's full mediating effect (Barron & Kenny, 1986). STR had a significant impact on SE ($\beta = 0.466$, $p < 0.001$, effect size = 0.046).

The moderating effect of GF was measured in AMOS as well. We tested the effect of STR on SE in the presence of GF. This moderation analysis was conducted by measuring the impact of GF, STR, and their interaction (STR x GF) on SE directly. GF was a predictor of SE ($\beta = 0.518$, $p < 0.01$, effect size = 0.018). The interaction term had no significant effect on SE ($\beta = -0.396$, $p > 0.01$, effect size = 0.007). We also tested the two-way interaction effect of GF and STR on SE through a simple slope plot, displayed in Fig. 3. This confirmed that GF had no observable moderating effect.

Some of the theorized control variables were found to influence SE, including class standing ($\beta = -0.083$, $p < 0.100$, effect size = 0.010); gender ($\beta = 0.099$, $p < 0.05$, effect size = 0.022); number of HyFlex classes taken ($\beta = 0.001$, $p < 0.100$, effect size = 0); and number of semesters in which online classes were taken ($\beta = -0.065$, $p > 0.100$, effect size = 0.003). The effects of these variables were controlled during the analysis to prevent bias.

7 Discussion

Educational institutions across the world have switched to remote or HyFlex teaching and learning during the COVID-19 pandemic. As the prolonged effect of COVID-19 and other situations that prompts to sudden switch to remote or HyFlex teaching and learning, it is

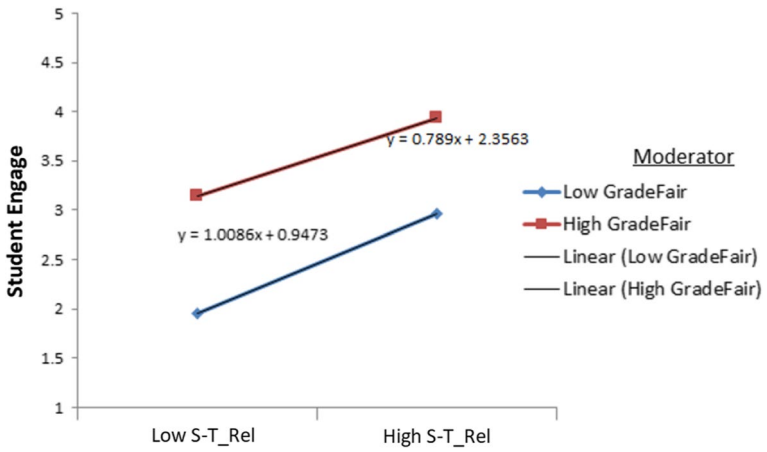

Fig. 3 Two-way interaction effect of GF and STR on SE. *S–T_Rel* student teacher relationship, *GradeFair* grade fairness

important to reflect on the experiences gained from this emergency online course delivery experiences. Understanding the changes introduced by the non-voluntary switch to online or HyFlex learning and their impact on other facets of teaching and learning can improve the quality of education. Using a sample of 329 college students in the United States, this study aimed to investigate impact of student's basic psychological needs on student engagement during after the shift to HyFlex or online learning-only course delivery. Specifically, we tested five hypotheses that concerned the impact of the change in social context for learning on the meeting of students' innate psychological needs and student engagement. We empirically tested the SSMMD model-driven relationships among the basic psychological needs and student engagement prompted by the change in the social context caused by the emergency online and HyFlex learning modes. The results supported hypotheses 2, 3, and 4 and rejected hypotheses 1 and 5.

First, the level of autonomy satisfaction, was relatively low compared to the other psychological needs, which indicates that students did not benefited from the supported they received during the emergency online learning. Students felt constrained in the HyFlex or online learning and felt limited freedom of choice in what they wanted to undertake. It is in contrast with the literature e.g. Chen et al. (2015) who found that the need for autonomy had a unique association with well-being. Students who were forced to stay away from their routine and peers may not have realized the support their teacher provided. Autonomy is central to SDT as it found to initiate and regulate behaviors that are driving the realization of other psychological needs (Ryan & Deci, 2017, p. 250). Some even call autonomy as meta-need compared to the other two needs, need for competence and need for relatedness, which are considered part of human functioning (Bandura, 1977). Our results, however showed that students had higher satisfaction with the other two needs.

Satisfaction with competence was higher than satisfaction with autonomy, which could be driven by the fact that students had more time to work on assignments. It has also been noted that several classes offered pass/fail option during the transitional period and students falsely may have felt that their need for competence is satisfied with a pass grade. We proposed that the individualized, autonomous learning environments can create optimal conditions for learners to experience themselves as competent based on the study of Niemiec and Ryan (2009). Both autonomy and competence are necessary conditions for intrinsic motivation, according to SDT (Ryan & Deci, 2017). Our findings supported this as the need for autonomy was fully mediated by the need for competence. The strongest path coefficient was found between grit and learning confidence (H2). This indicates that perseverance in learning activities completion results in confidence in learning is in harmony with self-regulated learning (SRL) literature and suggests that grit is an appropriate choice for measuring need for autonomy (Wolters & Hussain, 2015). Consistency of interest is a predictor of cognitive strategy use and positively impact academic achievement if mediated by SRL engagement, including goal-setting, self-monitoring, and self-reinforcement (Martin et al., 2022). This shows that autonomous students are more likely succeed if the they are confident in their learning. On the other hand, negative learning confidence is more likely impacting students traditionally in marginalized position, the emergency online learning literature identified this as vulnerable groups who are more impacted by the negative effects of learning confidence (Bartolic et al., 2022).

The literature has long established the common view of need for relatedness as a basic human need for existence. Students need to feel related to their parents, teachers, and peers and this relatedness has mainly been studied in the face-to-face content (Niemiec & Ryan, 2009; Ruzek et al., 2016; Stipek, 2002). We found that the teacher–student relationship is strongly correlated with student engagement (H4). The extant literature found mixed

results in relatedness and its positive impact. For example, Holzer et al. (2021) argues that relatedness exerted only a minor effect on positive emotions while Chiu (2021) argued that relatedness support were strong predictor of student engagement and digital support strategies helped to satisfy students' inherent basic psychological needs. Our model considered grading fairness as a moderator between student–teacher relationship and student engagement (H5). While grading fairness was found to be a significant predictor of student engagement, the interaction between student–teacher relationship and grading fairness had no significant effect on student engagement. While some students perceived that their effort and knowledge was not recognized during the HyFlex and online learning during the Covid-19 pandemic (Retta, 2020; Watanabe, 2020), a plausible reason for our results not support this hypothesis could lie in the emphasis of teacher support. Studies reflecting on teacher's input about their experiences during the pandemic revealed that worry for students, importance of relationship among other emergent supporting themes indicated their focus on caring for their students during the uncertain times of the pandemic (Kim et al., 2021; Tapani et al., 2022).

Our model reinforces and empirically verifies the interdependence of personal attributes and self-system processes for students in the HyFlex or online learning environment. Our data show that self-system processes have a considerable level of explanatory power, especially considering the large number of mechanisms described in the literature (e.g., characteristics of the school, the role of technology, emotional attachments). Below, we discuss the theoretical contributions and pedagogical implications of our findings.

7.1 Theoretical Contributions

This study is rooted in the literature on student engagement and self-determination theory within the broad domain of motivation. We approached student engagement from the perspective of meeting core psychological needs. We argue that student engagement largely depends on how well core psychological needs are satisfied, and our study emphasized the importance of the social context for learning and how it can shift, depending on the extent to which psychological needs are met.

Prior studies conceptualized student engagement in the face-to-face context, with recent studies considering HyFlex and online learning (Abou-Khalil et al., 2021; Carini et al., 2006). Our study contributes to the literature to focus on the non-voluntary aspect of remote learning, which impacts the way educators and students relate to this course delivery method. We found that teacher support and student–teacher relationship is the main driver of student engagement and that grit in conjunction with learning confidence has a strong impact on student engagement.

We also reconcile diverse findings on student engagement. Several theories and models have been employed and we tested the holistic SSMMD model based on Connell (1990) and Skinner et al. (2008, 2009). This model provides an overarching understanding of the self-system process and applied in the COVID-19 pandemic context. We proposed the change in the social context due to the pandemic impacted the self-variables (basic psychological needs), which in turn impacted the way they impacted student engagement.

Furthermore, we proposed that the need for autonomy, measured by grit as personal characteristic, is mediated by need for competence, measured by learning confidence. This mediating relationship has not been tested and we revealed a full mediating effect of learning confidence on the relationship between frit and student engagement. This adds to our current understating of perseverance and engagement in a context-specific setting. Prior

studies considered the triad of basic psychological needs as mediating constructs or all three of them mediated by other constructs, for example Frotadis et al. (2019) mediated the three psychological needs by work-life balance and measured their impact on well-being, while Fernet et al. (2013) studied the three psychological needs as mediators between job demands and burnout. However, the mediating role among the psychological needs have not been studied to this point, especially not in the online learning context.

We also explored the moderating role of grading fairness. While the perceived grading fairness had significant impact on student engagement, it had dismal moderating effect on student–teacher relationship and student engagement and our hypothesis was rejected. We theoretically contributed to the literature of the complex, multi-faceted construct of student-engagement (Fredricks et al., 2004).

This study offers a potential explanation to reconcile the divergent findings in prior studies on the impact of psychological needs on student engagement. The use of the these needs as indicator variables were mainly used in face-to-face settings and only limited studies explored their relationships in the online learning environment (Fullarton, 2002). This study focused on the context of emergency migration of courses to HyFlex and online delivery methods, which is not yet well understood (Chiu, 2022).

Finally, this study revealed that the shift in the innate psychological needs for students as the social context for learning changes with a shift to digital learning suggested a strong relationship between student–teacher relationship and student engagement. This suggests that weakened relationships with peers were replaced with an intensified focus on relationships with teachers (Ye et al., 2021). Within the framework of self-determination theory, this suggests that teachers need to heighten their focus on the context of social relationships in the digital teaching–learning space.

7.2 Pedagogical Implications

Our findings have important implications as related to our five hypotheses. Each set of empirically tested relationships are reflected on with pedagogical implications.

7.2.1 Grit and Student Engagement (H1)

The impact of GR on SE and LC supported Hypothesis 1. Specifically, students who have a mindset to remain committed to a task, idea, or project are more likely to succeed in a socially isolated class environment. To sustain such effort in a challenging learning environment, HyFlex or online learning-only classes should focus on continuous encouragement and support for students. This can be achieved through project work, whereby students can be held accountable for regular, smaller deliverables instead of a single, larger project (Credé et al., 2017). Further, according to Bashat (2014), a school culture and common vocabulary that encourage "intellectual aggressiveness" can help to sustain student engagement.

7.2.2 Mediating Effect of Learning Confidence on Grit and Student Engagement (H2)

The mediating effect of LC was revealed, as GR became non-statistically significant in the presence of LC as an intervening or mediating variable, which did not directly support Hypothesis 2, which predicted a direct relationship. The mediating effect of LC suggests that GR is not sufficient for student engagement in the HyFlex or online learning-only

class formats. Students need encouragement to participate, and, thus, teachers should use a detailed approach to project work that emphasizes learning complex concepts through hands-on exercises. This may increase students' confidence in their ability to deliver assignments in the HyFlex or online classroom.

7.2.3 Learning Confidence and Student Engagement (H3)

LC showed a statistically significant correlation with SE, supporting Hypothesis 3. Based on these findings, it is recommended that teachers seek direct input from students to encourage engagement through a variety of mediums. For example, mandatory posts to informal discussion forums may encourage otherwise reluctant students to ask questions, and technology can effectively facilitate such encouragement. Further, student engagement should be regularly and directly verified.

7.2.4 Student–Teacher Relationship and Student Engagement (H4)

STR was statistically significantly related to SE, supporting Hypothesis 4. As a key part of self-determination, students need to feel connected and related to find motivation to accomplish goals. Teachers need to understand the importance of this psychological need and follow the recommendations in the literature in regard to reciprocal influence—that learning interactions can lead to growth for both the learner and teacher—especially in an online environment. Teachers need to be aware of the additional roles that they fill in their students' education in digital platforms and be conscious of the need for flexibility, collaboration, mutuality, emotional investment, interdependence, and support for student identity (Bain, 2004; Davis, 2003). Teachers may utilize novel technological innovations to provide personalized feedback to enhance student learning and engagement (Pardo et al., 2019).

7.2.5 Grading Fairness as a Moderator (H5)

GF was found to have an impact on SE, but the interaction of GF and STR was statistically non-significant ($p > 0.100$) and failed to support the moderating effect predicted in Hypothesis 5. Students who found that their efforts were reflected in appropriate grades were more likely to remain engaged. Thus, GF can be supported through the providing of clear expectations, increased attention to student needs, and the opportunity for students to discuss their grades with the teacher.

8 Limitations and Future Directions

Data in this study were collected within a single university, and, thus, generalizability is limited. Future research should replicate this research in more diverse higher education settings and multiple universities. HyFlex or online learning-only course delivery techniques may vary greatly by institution type, and our model would benefit from testing with a diversity of student experiences and demographics (Lixiang et al., 2021). Further, we relied on self-reported data, yet objective measures (e.g., participation logs, assignment and participation scores) may provide more accurate results.

The heavy trimming of the constructs for learning confidence and grading fairness resulted in only two measures, yet they still measured the intended constructs in a valid

measure. We recommend that future researchers use other valid measures. It also may be worth exploring other variables that contribute to student engagement within the domain of our study. Future studies that include different configurations of antecedents and mechanisms will help to pinpoint the role of social context and supporting technology and the extent to which they influence motivation-based student engagement.

We purposefully excluded the last phase of the self-process, the outcome. We chose to exclude it as measuring the academic achievement is a complex construct that we did not want to rely on self-reported perceived accomplishments. It is recommended to use an objective measure to understand the outcome of the self-system process. Furthermore, self-reported scales were used in the process of gathering psychological needs and engagement data. Although self-reports are extensively used in behavioral and educational research, they provide only subjective information. Therefore, point out this limitation and recommend other data collection methods such as observations of teacher–student interactions in the classroom and teacher reports should be considered in future engagement research (Fredricks et al., 2004).

Finally, the results of this study suggest that the role of teachers shifts when relationship with peers are weakened. Further study is required to understand how students perceive their relationship with their peers, given that our study did not specifically measure this factor. We assumed that social isolation resulted in less direct contact with peers, as other studies suggested, and that students would feel detached as a result. Further, future studies should compare these findings with results from studies of peer relationships in face-to-face classroom settings.

9 Conclusion

The impact of social context on student engagement is complex, and researchers have explored mediating this relationship with process-based approaches, using comprehensive models that have implications for a wide range of strategies. There is substantial consensus among researchers, policymakers, and administrators that student engagement is greatly dependent on the social context within which a student's sense of self develops and motivation is promoted. These mechanisms of social interaction suggest that one's sense of self develops through the reflective appraisal of peers and self-system processes. Comprehensive studies have highlighted the importance of self-system processes and basic psychological needs. These studies, however, have neglected to fully explore the impact of changing social context on these needs and self-regulated motivational behaviors. In response, we proposed and empirically tested our student engagement model in the HyFlex or online only learning environment. Our study highlights the importance of teacher support and the mediating role of need for competence (learning confidence) between need for autonomy (grit) and student engagement in HyFlex or online learning-only learning environments.

Appendix 1

See Table 5.

Table 5 Univariate statistics of measures

Measure	Missing	Skewness	Kurtosis
GF_1	9	−0.755	0.270
GF_2	9	−0.725	−0.550
GF_3	9	−0.473	−0.856
GF_4	11	0.744	−0.601
GF_5	11	*−1.086*	0.456
Class	0	0.759	−0.871
Gender	0	0.163	*−1.802*
HyFlexLength	0	0.766	−0.219
OnlineLength	0	0.530	−0.187
Gr_1	0	0.123	−0.280
Gr_2	0	0.205	−0.359
Gr_3	0	0.308	−0.640
Gr_4	0	−0.209	−0.967
Gr_5	0	−0.244	−0.729
SE_1	0	−0.381	−0.687
SE_2	0	−0.103	−0.886
SE_3	0	−0.626	−0.437
SE_4	0	−0.452	−0.354
SE_5	0	−0.380	−0.724
GM_1	0	−0.427	−0.700
GM_2	0	−0.528	−0.326
GM_3	0	−0.126	*−1.014*
GM_4	0	−0.331	−0.645
GM_5	0	−0.320	−0.547
TS_1	0	−0.645	−0.341
TS_2	0	−0.622	−0.565
TS_3	0	−0.704	0.063
TS_4	0	*−1.129*	*1.083*
TS_5	0	*−1.249*	*1.491*
STR_1	0	−0.774	0.703
STR_2	0	−0.917	0.213
STR_3	0	*−1.046*	*1.086*
STR_4	0	−0.667	0.424
STR_5	0	−0.992	0.570
STR_6	0	*−1.427*	*2.504*
LC_1	0	−0.140	−0.972
LC_2	0	*1.038*	*1.520*
LC_3	0	0.872	−0.059
LC_4	0	0.030	−0.980
LC_5	0	−0.331	−0.671
LC_6	0	0.598	−0.157

Significance of italics mean that skewness and kurtosis values are falling between ± 1 but still below acceptable thresholds

Appendix 2

(A) Measures.

Construct	Variable	Measure
Class	Class	What is your current class standing?
Gender	Gender	Male/female
HyFlex length	HyFlexLength	How long have you been using Hyflex learning module?
Online length	OnlineLength	How long have you been part of (as a student) some form of online course delivery?
Grit (Duckworth a Quinn, 2009; Von Culin et al., 2014)	Gr_1	New ideas and projects sometimes distract me from previous ones
	Gr_2	I have been obsessed with a certain idea or project for a short period of time but later lost interest
	Gr_3	I often set a goal but later choose to pursue a different one
	Gr_4	I have difficulty maintaining my focus on projects that takes more than a few months to complete
	Gr_5*	Setbacks don't discourage me
Student engagement (Chemers et al., 2001; Gore, 2006; Khan, 2013; Pajares & Schunk, 2001)	SE_1	Study effectively on your own in independent/private study
	SE_2*	Respond to questions asked by a lecturer in front of everyone
	SE_3	Manage your workload to meet coursework deadlines
	SE_4	Produce your best work in coursework assignments
	SE_5	Ask your instructor questions about the material they are presenting
Student teacher relationship (Klem & Connell, 2004; Micari & Pazos, 2012)	TS_1*	My professor likes the other students in my class better than me
	TS_2*	My professor doesn't explain why we have to learn certain things in my class
	TS_3	My professor thinks what I say is important
	TS_4	My professor is fair with me
	TS_5	My professor's expectations of me are reasonable
	STR_1	My professor is the kind of professional I would like to emulate, regardless of the career I end up pursuing
	STR_2	I feel comfortable asking my professor questions in class
	STR_3	In general, my professor respects the academic abilities of the students in the class
	STR_4*	I see my professor as a role model
	STR_5	I feel comfortable going to my professor's office hours and receive the expected help
	STR_6	My professor respects me as a person

Construct	Variable	Measure
Learning confidence (Wang, 2013)	LC_1*	I am often too busy with my work responsibilities and it negatively impacts my school performance
	LC_2*	I am well versed using the Internet to find suitable learning resources when I feel stuck during my studies
	LC_3*	I feel I have difficulty using computers and the Internet to successfully participate in online classes
	LC_4	I often feel lonely and discouraged when studying for classes
	LC_5	It harms my studies that I have little chance to learn together with fellow students
	LC_6*	I feel my grades are aligned what I expected from my online classes
Grading fairness (Ross & Broh, 2000; York et al., 2015)	GF_1*	What is your expected GPA for the semester you are taking (or have taken) online classes?
	GF_2	I believe my GPA reflects my effort I put in my studies
	GF_3	I believe my GPA reflects my knowledge in my classes
	GF_4*	I feel Hyflex/online class contributes to my learning better than in-person class
	GF_5*	I believe I could have better learning in-person than Hyflex/online

*Omitted due to undermining construct validity

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Declarations

Conflict of interest None of the authors of this study have any conflicts of interest.

Statement on Open Data and Ethics We can provide the data set used for the study and we followed all ethical guidelines during the design of questionnaire, collection and analysis of data. The lead author's institution' IRB approved the data collection as exempt.

Originality This study is original and the manuscript has neither been published elsewhere nor currently being considered for publication elsewhere.

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