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Need satisfaction and need dissatisfaction: A comparative study of online and face-to-face learning contexts

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ABSTRACT

The distinction between the bright and the dark sides of basic psychological needs has been documented in face-to-face contexts. However, no one has examined the distinctive effects of need satisfaction and need dissatisfaction in online learning contexts. First, we validated the Basic Psychological Needs Scale among 693 undergraduates in online courses. However, we found one autonomy item and two relatedness items might need modifications to fit the online learning contexts. Second, we tested a motivation and learning model with both online (495 undergraduates) and face-to-face (519 undergraduates) samples. Consistent with previous findings in face-to-face contexts, need satisfaction and need dissatisfaction demonstrated distinctive effects on students' motivation and learning outcomes in online learning contexts. The current research contributes to the developing field of online learning by applying BPN into the online courses and comparing the motivation model between online and face-to-face learning contexts.

1. Introduction

With the increasing accessibility of the internet in the past decade, online learning is becoming an integral part of most higher education institutions (Bowers & Kumar, 2015; Porter, Graham, Spring, & Welch, 2014). In 2010, 65.5% of higher education institutions in the United States offered online courses (Allen & Seaman, 2011) and the online enrollment has been steadily growing. In Fall 2016, 31.6% of all higher education students had taken at least one online course (Seaman, Allen, & Seaman, 2018). Despite the explosive growth of online learning in higher education, it has also raised some pressing concerns regarding low student engagement and high dropout rates in online courses and programs. For example, non-completion rates as high as 75% have been reported in multiple studies (e.g., Carr, 2000; Jun, 2005; Rochester & Pradel, 2008). Though various factors can account for the high attrition rates in online learning environments, motivation, as a salient component of learning in any educational environment, has drawn increased research attention (e.g., Broadbent & Poon, 2015; Chen & Jang, 2010; Miltiadou & Savenye, 2003). For example, researchers using a social cognitive view have examined the application of various self-regulated learning strategies in online learning environments and argued that online courses require learners to demonstrate higher levels of self-regulation, self-motivation, and time commitment compared to traditional face-to-face classrooms (e.g., Broadbent & Poon, 2015; Golladay, Prybutok, & Huff, 2000; Serwatka, 2003). In addition to the self-regulation strategies, contextual support in the online courses is critical. Online learners need a variety of support from instructors as well as their peers (Chen & Jang, 2010). Some researchers are concerned that not being present in the same location at the same time eliminates the opportunities for immediate social interactions to occur among students and instructors in online learning (Smart & Cappel, 2006). As a result, learners in online learning contexts reported negative experiences, such as feelings of isolation, frustration, anxiety, and confusion (e.g., Piccoli, Ahmad, & Ives, 2001). Bowers and Kumar (2015) have pointed out that lack of connectedness and instructor presence could lead to student disengagement. Researchers have found that students are more likely to withdraw or fail when they perceive a lack of social interactions and instructor presence (e.g., Capra, 2011; Rovai & Wighting, 2005; Trello, 2007).

Self-determination theory (SDT) is an appropriate theoretical framework for addressing learning and motivation challenges in online learning, as it enables researchers to examine the impact of contextual factors on students' motivation and learning (Chen & Jang, 2010). It is one of the most comprehensive and empirically supported motivation

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theories in educational settings (Pintrich & Schunk, 2002), with a focus on how social-contextual factors support or thwart people's thriving through the satisfaction of their basic psychological needs (Ryan & Deci, 2017). The emphasis on the importance of social-contextual support is especially valuable for online learning research, as previous researchers put a great deal of responsibility on online learners and tended to overlook the influences of social and contextual factors on individuals' motivation. According to SDT, humans seek to satisfy three basic psychological needs for autonomy, competence, and relatedness (Ryan & Deci, 2017). *Autonomy* refers to the volition to self-regulate one's experiences or actions. *Competence* is the ability to effectively accomplish tasks. *Relatedness* refers to the feelings of being connected with others. These three basic and universal needs must be satisfied for psychological growth and wellness (Ryan & Deci, 2017).

In educational contexts, to satisfy students' needs for autonomy, instructors can offer projects and assignments enabling students to work in their own way and avoid using controlling language which puts undue pressures on students by the frequent use of words such as “must” and “should.” To fulfill students' needs for competence, instructors could provide instructive feedback that guides students to mastery by offering progress-enabling scaffolding when students have misconceptions or difficulties. To enhance the satisfaction of students' needs for relatedness, instructors should reply promptly to students' questions and comments, and create opportunities for students to work with one another. Applying SDT to traditional face-to-face higher education environments has shown numerous positive effects on students' motivation and learning (e.g., Black & Deci, 2000; Grolnick & Ryan, 1989; Kusurkar, Ten Cate, Vos, Westers, & Croiset, 2013; Taylor et al., 2014; Vansteenkiste, Simons, Lens, Soenens, & Matos, 2005). Numerous studies have indicated that providing an autonomy-supportive learning environment fosters the satisfaction of students' basic psychological needs, which promote students' intrinsic and well-internalized motivations and in turn enhance students' learning (e.g., Jang, Kim, & Reeve, 2012; Reeve, Jang, Hardre, & Omura, 2002; Williams & Deci, 1996). However, few attempts have been made to examine the application of SDT in online learning in higher education (Hsu, Wang, & Levesque-Bristol, 2019; Chen & Jang, 2010).

One notable exception is the study by Chen and Jang (2010). With an aim to test the validity of SDT in online contexts using structural equation modeling (SEM), Chen and Jang (2010) tested six parallel models to illustrate the relation between the basic psychological needs and learning outcomes. In their models, contextual support was positively associated with basic psychological needs, which in turn, was positively associated with self-determined motivation. However, self-determined motivation failed to predict any of the learning outcomes including engagement, achievement, perceived learning, and course satisfaction. As one of the earliest studies that applied the SDT model in the online learning context, Chen and Jang’s (2010) study deepened our understanding of online learners' motivation and provided implications for online teaching practices. However, they did not fully explain why self-determined motivation has been found to be associated with learning outcomes in the face-to-face learning context (Standage, Duda, & Ntoumanis, 2006; Vallerand, Fortier, & Guay, 1997) but not in the online learning environment. Part of the issue in Chen and Jang (2010) could have been methodological because self-determined motivation was modeled as a single observed variable in the SEM. In another study, we re-examined the SDT-based model proposed by Chen and Jang (2010) within online learning environments by modeling self-determined motivation as a latent variable with multiple indicators instead of an observed variable and found significant relations between self-determined motivation and course grade, perceived learning gains, and knowledge transfer (Hsu et al., 2019).

Recently, researchers have paid more attention to the distinction between the bright and the dark sides of basic psychological needs (e.g., Chen et al., 2015; Haerens, Aelterman, Vansteenkiste, Soenens, & Van Petegem, 2015; Jang, Kim, & Reeve, 2016; Sheldon & Hilpert, 2012).

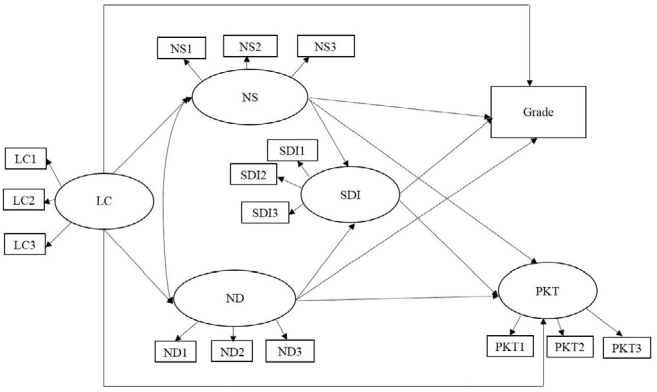

Fig. 1. Hypothesized SEM model, LC = Learning Climate, NS = Need Satisfaction, ND = Need Dissatisfaction, SDI = Self-determination Index, PKT = Perceived Knowledge Transfer.

However, to the best of our knowledge, no one has examined the distinctive effects of need satisfaction and need dissatisfaction in online learning contexts. Therefore, in the present study we modeled basic psychological needs as a broad two-dimensional construct (i.e., need satisfaction and need dissatisfaction). To study the distinct roles of need satisfaction and need dissatisfaction in educational settings, we drew upon the integrative model for learning and motivation (IMLM) which was developed under the SDT framework by the authors (Levesque-Bristol, Sell, & Zimmerman, 2006) to model the associations among learning environment, students' motivation, and learning outcomes in higher education. As seen in Fig. 1, we hypothesized that an autonomy-supportive learning climate would foster college students' self-determined motivation and lead to better learning outcomes through the mediating effects of need satisfaction and need dissatisfaction in online learning environments. Moreover, there is no evidence available regarding whether basic psychological needs function similarly across face-to-face and online learning environments. Previous comparative studies of face-to-face and online learning demonstrated discrepancies in a number of aspects, such as students' satisfaction with the course (e.g., Summers, Waigandt, & Whittaker, 2005), learning outcomes (e.g., Campbell, Gibson, Hall, Richards, & Callery, 2008), evaluation of teaching (e.g., Kelly, Ponton, & Rovai, 2007), and association between learning style preferences and student success (e.g., Aragon, Johnson, & Shaik, 2002). Therefore, we hypothesize that the strengths of the relations between need satisfaction, need dissatisfaction and other related constructs may vary across the two contexts.

To be able to test the proposed model, we need to examine the validity of the basic psychological needs scale in online learning environments. In many face-to-face educational studies, students' basic psychological needs in a class were measured using the Basic Psychological Needs Scale (BPNS; e.g., Filak & Sheldon, 2010; Gagne, 2003; Levesque-Bristol, Knapp, & Fisher, 2010; Thøgersen-Ntoumani & Ntoumanis, 2007). The language of the questions might have been slightly modified to fit specific contexts in different studies. BPNS comprises 12 positively-worded items (e.g. I really like the people I interact with) and nine negatively-worded items (e.g. Often, I do not feel very competent). Recently, Johnston and Finney (2010) have found that the negatively-worded items of BPNS share common variance that was not explained by the need satisfaction factor(s). Sheldon and Hilpert (2012) claimed that positively and negatively worded need-items may have distinctive interpretations and effects and suggested that need satisfaction, represented by the positively worded items, and need dissatisfaction, represented by the negatively worded items, should be treated separately. They proposed that BPNS contains five latent variables: autonomy, competence, relatedness, need satisfaction, and need dissatisfaction. With a series of confirmatory factor analyses, they demonstrated that the three-latent need factors (autonomy,

Table 1
Summary of study one and study two.

	Purpose	Sample	Method
Study One	Examining construct validity of BPNS in online learning contexts	Online Course Takers	Confirmatory factor analysis (CFA)
Study Two	Comparing the dynamics of SDT elements in face-to-face and online learning environments	Online Course Takers Face-to-Face Couse Takers	Structural Equation Modeling (SEM) Invariance Analysis

competence, and relatedness) and two-latent method factors (need satisfaction and need dissatisfaction) model produced sound evidence of convergent and discriminant validity. As far as we know, no one has examined the construct validity of BPNS in online learning contexts. We believe the three-latent need factors and two-latent method factors model of BPNS can be applied to online settings. However, some of the BPNS items, especially the relatedness items, might not be applicable to online learning situations, because the social interactions of students with their instructors and peers vary between online and face-to-face learning contexts (Otter et al., 2013; Robinson & Hullinger, 2008). Therefore, another aim of the present study is to investigate the construct validity of the BPNS as proposed and tested by Sheldon and Hilpert (2012) in online learning environments. Table 1 highlights the major aspects we investigate in Study One and Two, followed by detailed descriptions of each study in the next section.

2. Study One: validation of BPNS in online learning contexts

The BPNS has been used in a few studies to assess online students' basic psychological needs (e.g., Hsu et al., 2019; Sørebø, Halvari, Gulli, & Kristiansen, 2009); however, there has not been any rigorous study of the application of the scale within online learning contexts. Our first research question is whether BPNS has an adequate validity within online learning contexts. To answer this question, we tested the three-latent need factors and two-latent method factors model proposed by Sheldon and Hilpert (2012). The construct validity of BPNS has been demonstrated by Sheldon and Hilpert (2012) through traditional face-to-face learning contexts. All the positively-worded items can be viewed as need satisfaction, and all the negatively-worded items can be viewed as need dissatisfaction.

2.1. Method

2.1.1. Participants

Participants in the current investigation were undergraduate students at a large, Midwestern research intensive university. Upon IRB approval, students received a 10-min survey via email assessing their perceptions about a course in which they were currently enrolled. Surveys were sent out at the beginning of the semester. Only students enrolled in online courses were included in the current study. The sample size of Study One was 646. They were from various academic disciplines including Agriculture, Health and Human Science, Science, Liberal Arts, Technology, and Engineering. See Table 2 for a list of participant demographics.

2.1.2. Measures

The 21-item BPNS scale contains seven autonomy items, six competence items, and eight relatedness items (BPNS; Levesque-Bristol et al., 2010). The autonomy subscale contains four positive items and three negative items; the competence subscale contains three positive items and three negative items; and the relatedness subscale contains five positive items and three negative items. The items were modified by the authors (Levesque-Bristol et al., 2010) to reflect a classroom situation. The modified BPNS was administered with the instructions, "please indicate how true each of the following statements is for you given your specific experiences with the course." Students responded to the items on a seven-point Likert scale anchored by strongly disagree (1) and strongly agree (7). Example items include "I am free to express my ideas and opinions in this course" (autonomy, positive item), "I feel pressured in this course" (autonomy, negative item), "Most days I feel a sense of accomplishment from this course" (competence, positive item), "I do not feel very competent in this course" (competence, negative item), "I really like the people in this course" (relatedness, positive item), and "The people in this course do not seem to like me much" (relatedness, negative item).

Table 2
Participant demographics.

	Study One	Study Two- Online	Study Two- Face to Face
Total sample	693	495	519
URM	51	38	35
Gender			
Female	415	332	255
Male	273	163	264
Unknown	5	0	0
Ethnicity			
White	362	277	346
Asian	35	21	22
Hispanic	28	14	13
African American	19	17	16
2 or more	11	12	8
International	222	144	99
Other	12	10	15
Class Rank			
Freshman	171	99	164
Sophomore	158	113	142
Junior	122	110	114
Senior	226	164	90
Other	16	9	9

Note: URM = Underrepresented Minority.

2.1.3. Data analysis

The structure of BPNS was tested with confirmatory factor analysis (CFA) using LISREL 8.80 (Jöreskog & Sörbom, 2006). Specifically, we tested the five-factor model (see Fig. 2), which was confirmed by Sheldon and Hilpert (2012) in face-to-face environments. This model contains three general need factors (i.e., autonomy, competence, and relatedness) and two method factors (need satisfaction and need dissatisfaction). According to SDT, all three need factors are positively correlated. In terms of the relation between the two method factors, Sheldon and Hilpert (2012) demonstrated a lack of discriminant validity across the satisfaction and dissatisfaction methods for BPNS, which suggested that the two method factors were correlated. The following commonly used goodness-of-fit indices were examined to evaluate model fit in the present study: the standardized root mean square residual (SRMR), the root mean square error of approximation (RMSEA), the non-normed fit index (NNFI), the incremental fit index (IFI), and the comparative fit index (CFI). The NNFI, IFI, and CFI values range from 0 to 1, and values above 0.90 are indicative of acceptable fit. SRMR and RMSEA values also range between 0 and 1, but values closer to 0 are indicative of a better fitting model. Values below 0.08 indicate a good fitting model (Hu & Bentler, 1999). A significant factor loading, as determined by a standardized coefficient of 0.30 or above, indicates that the item is a good measure of the underlying factor (Hatcher, 1994).

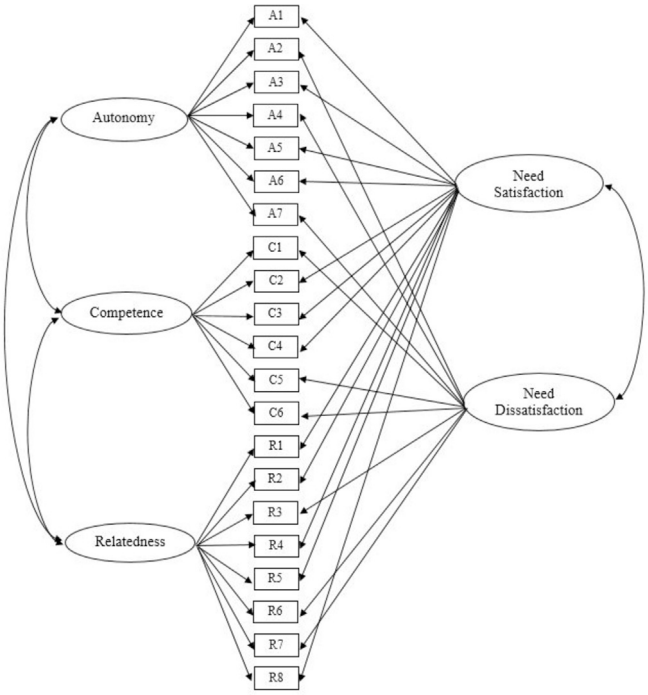

Fig. 2. Hypothesized CFA model. A = Autonomy, C = Competence, R = Relatedness.

2.2. Results and discussion

Descriptive statistics of the BPNS items and item correlations for the online samples, including values of skewness and kurtosis, are presented in Table 3. Results of the CFA indicated that the model fit was adequate, χ^2 (169) = 1113.63, $p < .001$, NNFI = 0.93, IFI = 0.94, CFI = 0.94, SRMR = 0.08, RMSEA = 0.10. While the χ^2 test was significant, this test is very sensitive, especially when the sample size is large, and a significant χ^2 statistic is expected in most CFA models. Parameter estimates for the hypothesized model are presented in Table 4. All of the factor loadings were significant ($p < .05$). However, the fourth item of autonomy, the third item of relatedness, and the sixth item of relatedness loaded on autonomy and relatedness in an unexpected direction. That is, students in online courses did not perceive these items as need dissatisfaction. Examination of the wording of the third item ("I pretty much keep to myself when in this course") and the sixth item ("There are not many people in this course that I am close to") of relatedness revealed the items may not be applicable to measure relatedness dissatisfaction in online learning contexts, because not being present in the same location at the same time is one of the characteristics of online learning. Having high scores on these questions does not necessarily indicate low perceptions of relatedness. In addition, the fourth item of autonomy ("When I am in this course, I have to do what I am told") might not apply to educational contexts. Students may feel that they are obligated to follow teachers' instructions. For example, they have to submit their homework before the deadline.

We further tested a CFA model without these items. The model fit was better χ^2 (118) = 711.65, $p < .001$, NNFI = 0.95, IFI = 0.96, CFI = 0.96, SRMR = 0.09, RMSEA = 0.09. All of the factor loadings were significant ($Z > 1.96$, $p < .05$) with an exception of the seventh item of autonomy ($Z = -1.81$, $p = .07$). We did not eliminate this item from the following analyses because examination of the content of this item ("There is not much opportunity for me to decide for myself how to go about my coursework") indicated that this item could provide useful information regarding need dissatisfaction in online learning environments. However, we suggest that researchers use this item with caution in online learning contexts. Furthermore, we found that some factor loadings became smaller after eliminating the problematic items (e.g., most of the relatedness items). We believe it is because part of the variance in these items has been further explained by need satisfaction and need dissatisfaction. The increasing factor loadings on the method latent constructs supported our inference. Standardized factor loadings and Cronbach's alpha reliabilities for each of the factors were presented in Table 5.

In both models, the factor of autonomy was positively associated with competence (21-item: $r = 0.88$, $p < .001$; 18-item: $r = 0.77$, $p < .001$) and relatedness (21-item: $r = 0.82$, $p < .001$; 18-item: $r = 0.58$, $p < .001$). The factor of relatedness was positively associated with competence (21-item: $r = 0.64$, $p < .001$; 18-item: $r = 0.40$, $p < .001$). Surprisingly, need satisfaction was positively correlated with need dissatisfaction (21-item: $r = 0.54$, $p < .001$; 18-item: $r = 0.40$, $p < .001$), which suggested that positively and negatively worded items in BPNS were not simply opposites in online settings. Students in online learning are likely to perceive need satisfaction and need dissatisfaction at the same time. For example, students may perceive that "people in this course tell me I am good at what I do" (the second item of competence) based on the feedback they receive from the instructor or the grades they achieve; however, they may also feel that "they are not very competent in the course" (the first item of competence) because they have higher expectations of themselves than the instructors have. This has been supported by the positive correlation ($r = 0.31$) found in the present study.

Study One provided initial evidence for applying BPNS in online learning contexts. The three-latent need factors and two-latent method factors model identified by Sheldon and Hilpert (2012) through face-to-face contexts demonstrated acceptable fit with the online sample. Yet, we found one autonomy item and two relatedness items which might need modifications to fit the online learning contexts. The moderate correlation between need satisfaction and need dissatisfaction confirmed that the positively and negatively worded need-items are not simply psychometric opposites. Results of recent studies have shown that need satisfaction and dissatisfaction may have different substantive interpretations and effects (Bartholomew, Ntoumanis, Ryan, Bosch, & Thøgersen-Ntoumani, 2011; Costa, Ntoumanis, & Bartholomew, 2015; Sheldon & Gunz, 2009). In addition, the unexpected positive correlation between need satisfaction and need dissatisfaction suggested that students in the online learning contexts may perceive those items differently than the students in the face-to-face learning contexts. More research is needed to replicate and explain the finding.

3. Study two: invariance analysis across online and traditional face-to-face learning contexts

Study Two extended Study One in two ways. First, we examined the SDT model with SEM. We hypothesized that an autonomy supportive learning climate would foster college students' self-determined motivation and lead to better learning outcomes through the mediating effects of need satisfaction and need dissatisfaction. Second, a more diverse sample was recruited. Apart from students from online courses, we also sampled students from traditional face-to-face courses to examine whether need satisfaction and need dissatisfaction would yield similar relations to learning climates and outcomes across these two learning contexts.

3.1. Methods

3.1.1. Participants

Participants were undergraduate students from the same university as Study One. The online sample includes 495 students who enrolled in online courses during the semester. The face-to-face sample includes 519 students who enrolled in traditional face-to-face courses. They were from various academic disciplines including Agriculture, Health and Human Science, Science, Liberal Arts, Technology, and

Table 3
Study One: Descriptive Statistics and Correlation Coefficients between All Items (N = 646).

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Autonomy 1	1.00																				
Autonomy 2 (R)	0.09	1.00																			
Autonomy 3	0.40	0.02	1.00																		
Autonomy 4 (R)	0.33	0.32	0.27	1.00																	
Autonomy 5	0.43	0.09	0.69	0.25	1.00																
Autonomy 6	0.45	0.06	0.51	0.37	0.49	1.00															
Autonomy 7 (R)	−0.11	0.52	0.04	0.20	0.11	0.01	1.00														
Competence 1 (R)	0.08	0.65	−0.05	0.18	0.05	−0.01	0.48	1.00													
Competence 2	0.29	0.26	0.29	0.20	0.46	0.29	0.22	0.31	1.00												
Competence 3	0.56	0.17	0.51	0.45	0.53	0.54	0.05	0.10	0.47	1.00											
Competence 4	0.42	0.03	0.53	0.28	0.61	0.49	0.07	−0.03	0.46	0.63	1.00										
Competence 5 (R)	0.11	0.52	−0.01	0.25	0.04	0.15	0.47	0.56	0.24	0.11	−0.01	1.00									
Competence 6 (R)	−0.01	0.56	−0.03	0.11	0.07	−0.08	0.58	0.65	0.25	−0.01	0.01	0.51	1.00								
Relatedness 1	0.36	0.14	0.57	0.30	0.61	0.41	0.13	0.10	0.46	0.49	0.49	0.09	0.06	1.00							
Relatedness 2	0.40	0.29	0.34	0.37	0.37	0.46	0.11	0.27	0.52	0.50	0.38	0.26	0.17	0.54	1.00						
Relatedness 3 (R)	0.09	0.12	0.31	0.31	0.27	0.36	0.27	0.06	0.10	0.18	0.20	0.24	0.14	0.28	0.11	1.00					
Relatedness 4	0.40	0.34	0.43	0.37	0.42	0.45	0.25	0.28	0.44	0.53	0.47	0.30	0.18	0.51	0.56	0.18	1.00				
Relatedness 5	0.42	0.24	0.45	0.34	0.50	0.55	0.15	0.22	0.57	0.57	0.51	0.29	0.14	0.53	0.62	0.21	0.62	1.00			
Relatedness 6 (R)	0.17	0.21	0.19	0.30	0.14	0.26	0.23	0.20	0.21	0.17	0.17	0.31	0.30	0.12	0.24	0.27	0.12	0.20	1.00		
Relatedness 7 (R)	0.12	0.53	0.09	0.25	0.17	0.17	0.50	0.53	0.33	0.17	0.16	0.59	0.55	0.05	0.17	0.28	0.32	0.24	0.32	1.00	
Relatedness 8	0.40	0.28	0.45	0.39	0.44	0.55	0.14	0.22	0.48	0.49	0.43	0.24	0.15	0.53	0.67	0.22	0.58	0.65	0.21	0.14	1.00
Mean	4.65	3.83	4.62	4.77	4.35	4.58	3.66	3.82	4.19	4.68	4.35	3.96	3.77	4.31	4.48	4.66	4.10	4.31	4.72	3.83	4.54
SD	1.59	1.64	1.46	1.40	1.45	1.32	1.55	1.57	1.27	1.37	1.40	1.37	1.65	1.32	1.22	1.50	1.31	1.17	1.41	1.31	1.11
Skew	−0.48	−0.08	−0.38	−0.56	−0.20	−0.24	0.02	−0.11	−0.16	−0.46	−0.17	−0.10	0.05	−0.08	0.00	−0.30	0.02	0.03	−0.27	−0.15	0.11
Kurtosis	−0.35	−0.64	−0.11	0.27	−0.04	0.46	−0.47	−0.57	0.73	0.30	−0.07	0.05	−0.68	0.45	0.95	−0.23	0.65	1.24	−0.04	0.66	1.19

Note: R indicates negatively-worded items.

Table 4
Study One: Factor Loadings for All 21 Items with Online Samples (N = 646).

	Autonomy	Competence	Relatedness	Need Satisfaction	Need Dissatisfaction
Autonomy 1	.40*			.47*	
Autonomy 2 (R)	-.26*				.71*
Autonomy 3	.68*			.39*	
Autonomy 4 (R)	.27*				.42*
Autonomy 5	.66*			.46*	
Autonomy 6	.52*			.50*	
Autonomy 7 (R)	-.16*				.65*
Competence 1 (R)		-.41*			.66*
Competence 2		.16*		.69*	
Competence 3		.54*		.62*	
Competence 4		.67*		.50*	
Competence 5 (R)		-.29*			.67*
Competence 6 (R)		-.33*			.68*
Relatedness 1			.69*	.49*	
Relatedness 2			.27*	.74*	
Relatedness 3 (R)			.41*		.36*
Relatedness 4			.26*	.72*	
Relatedness 5			.30*	.79*	
Relatedness 6 (R)			.11*		.42*
Relatedness 7 (R)			-.20*		.74*
Relatedness 8			.37*	.71*	

Note: R indicates negatively-worded items. *$p < .05$.

Table 5
Study One: Factor Loadings for 18 Items with Online Samples and the Reliabilities for the Factors (N = 646).

	Autonomy	Competence	Relatedness	Need Satisfaction	Need Dissatisfaction
Autonomy 1	.26*			.55*	
Autonomy 2 (R)	-.23*				.71*
Autonomy 3	.65*			.51*	
Autonomy 5	.66*			.56*	
Autonomy 6	.30*			.63*	
Autonomy 7 (R)	-.07				.67*
Competence 1 (R)		-.37*			.68*
Competence 2		.12*		.72*	
Competence 3		.40*		.70*	
Competence 4		.65*		.58*	
Competence 5 (R)		-.32*			.64*
Competence 6 (R)		-.21*			.73*
Relatedness 1			.73*	.61*	
Relatedness 2			.13*	.79*	
Relatedness 4			.12*	.75*	
Relatedness 5			.09*	.84*	
Relatedness 7 (R)			-.18*		.73*
Relatedness 8			.12*	.79*	
Alpha Reliability	.66	.70	.82	.92	.88

Note: R indicates negatively-worded items. *$p < .05$.

Engineering. Upon IRB approval, students received a 10-min survey via email assessing their perceptions about a course they were currently enrolled in. Surveys were distributed at the end of the semester. Students completed the survey based on their experience in a specific course. See Table 2 for a list of participant demographics.

3.1.2. Measures

3.1.2.1. Learning Climate. The Learning Climate Questionnaire measures students' perceptions of autonomy supportiveness of the instructor (LCQ; Williams & Deci, 1996). We used a short version of the questionnaire which incorporates six items (Jang et al., 2012). Students responded to the questions on a seven-point Likert scale from 1 ("strongly disagree") to 7 ("strongly agree"). Internal consistency coefficients of the LCQ in our study were very high (Online: $\alpha = 0.96$; face-to-face: $\alpha = 0.95$). In order to test the SEM, three LCQ indicators were created by averaging pairs of the six items.

3.1.2.2. Basic psychological needs. The same BPNS scale (BPNS; Levesque-Bristol et al., 2010) was used as a measure of students' perceptions of need satisfaction and need dissatisfaction. Based on the findings of Study One, the fourth item of autonomy, the third item and the sixth item of relatedness are not applicable within online learning contexts. Thus, only 18 items were used in study two to measure students' perception of need satisfaction and need dissatisfaction. Need satisfaction contained 12 items, and need dissatisfaction contained six items. In the current study, the Cronbach's alpha coefficients of need satisfaction (Online: $\alpha = 0.91$; face-to-face: $\alpha = 0.93$) and need dissatisfaction (Online: $\alpha = 0.82$; face-to-face: 0.84) were satisfactory. In order to test the SEM, three indicators were created for need satisfaction by averaging four of the 12 items and three indicators were created for need dissatisfaction by averaging pairs of the six items.

3.1.2.3. Motivation. The Situational Motivation Scale (SIMS; Guay, Vallerand, & Blanchard, 2000; Levesque-Bristol et al., 2010) was employed to assess students' perceptions of their reasons for participating in the course. The 18-item scale measures the six forms of motivation proposed by SDT (Deci & Ryan, 2000): intrinsic motivation, integration, identification, introjection, external

Table 6
Study Two: Descriptive Statistics and Correlation Coefficients between All Constructs (n1 = 452; n2 = 480).

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. Learning Climate	1.00											
2. Need Satisfaction	.62* (.72*)	1.00										
3. Need Dissatisfaction	.11* (−.34*)	.23* (−.32*)	1.00									
4. Autonomy Satisfaction	.61* (.74*)	.91* (.93*)	.08 (−.31*)	1.00								
5. Autonomy Dissatisfaction	.06 (−.32*)	.12* (−.30*)	.87* (.87*)	.00 (−.33*)	1.00							
6. Competence Satisfaction	.54* (.68*)	.87* (.89*)	.15* (−.29*)	.70* (.80*)	.07 (−.27*)	1.00						
7. Competence Dissatisfaction	.09* (−.35*)	.24* (−.29*)	.93* (.94*)	.08* (−.30*)	.65* (.70*)	.15* (−.30*)	1.00					
8. Relatedness Satisfaction	.54* (.55*)	.92* (.91*)	.36* (−.27*)	.74* (.74*)	.23* (−.22*)	.72* (.68*)	.38* (−.21*)	1.00				
9. Relatedness Dissatisfaction	.21* (−.09*)	.26* (−.19*)	.70* (.70*)	.18* (−.12*)	.53* (.48*)	.22* (−.07)	.52* (.56*)	.29* (−.31*)	1.00			
10. SDI	.37* (.58*)	.43* (.60*)	-.44* (−.54*)	.43* (.56*)	-.44* (−.46*)	.53* (.69*)	-.41* (−.53*)	.27* (.43*)	-.21* (−.33*)	1.00		
11. PKT	.51* (.61*)	.65* (.72*)	-.04 (−.31*)	.63* (.66*)	-.05 (−.26*)	.60* (.79*)	-.07 (−.32*)	.55* (.56*)	.12* (−.15*)	.60* (.67*)	1.00	
12. Grade	.15* (.19*)	.12* (.20*)	-.19* (−.21*)	.09* (.19*)	-.14* (−.20*)	.12* (.20*)	-.21* (−.20*)	.12* (.15*)	-.07 (−.11*)	.23* (.16*)	.19* (.17*)	1.00
Mean	4.62 (5.32)	4.28 (4.92)	3.80 (3.38)	4.38 (4.88)	3.74 (3.61)	4.26 (4.64)	3.88 (3.37)	4.22 (5.13)	3.70 (2.97)	3.51 (7.04)	4.54 (5.04)	3.04 (3.43)
SD	1.64 (1.43)	1.05 (1.10)	1.15 (1.22)	1.22 (1.26)	1.35 (1.39)	1.23 (1.31)	1.31 (1.36)	1.09 (1.11)	1.36 (1.48)	9.11 (11.94)	1.26 (1.44)	1.00 (0.79)

Note: *$p < .05$, *n1* represents the sample size of the online learning group, *n2* represents the sample size of the face-to-face group, numbers in parentheses represent the values for the face-to-face group, SDI = Self-Determination Index, PKT = Perceived Knowledge Transfer.

motivation, and amotivation. Students responded to the questions on a seven-point Likert scale from 1 ("strongly disagree") to 7 ("strongly agree"). Internal consistency was very good for all six subscales: intrinsic (Online: $\alpha = 0.89$; face-to-face: $\alpha = 0.96$), integration (Online: $\alpha = 0.76$; face-to-face: $\alpha = 0.85$), identification (Online: $\alpha = 0.93$; face-to-face: $\alpha = 0.91$), introjection (Online: $\alpha = 0.82$; face-to-face: $\alpha = 0.84$), extrinsic (Online: $\alpha = 0.76$; face-to-face: $\alpha = 0.81$) and amotivation (Online: $\alpha = 0.76$; face-to-face: $\alpha = 0.83$). In order to predict overall quality of motivation, one common approach is to calculate the individuals' self-determination index (SDI; Levesque-Bristol et al., 2010). SDIs were calculated by weighting the types of motivation represented by the items in function of their underlying level of self-regulation (See Eqn. (1)). In order to test the SEM, we used one item from each subscale to calculate three SDI indicators.

$$SDI = 3 * (IM) + 2 * (INTEG) + 1 * (IDEN) - 1 * (INTRO) - 2 * (ER) - 3 * (AM) \quad (1)$$

3.1.2.4. Perceived Knowledge Transfer. The Perceived Knowledge Transfer Scale (PKTS; Richards, Levesque-Bristol, Zissimopoulos, Wang, & Yu, 2019) was used to measure the extent to which students perceive that the information learned in class would be helpful for future courses and for their career. The PKTS contains eight items, all of which used a seven-point Likert scale ranging from 1 ("strongly disagree") to 7 ("strongly agree"). Internal consistency coefficients of the PKTS in our study were very high (Online: $\alpha = 0.97$; face-to-face: $\alpha = 0.96$). To test the SEM, we created three PKTS indicators by averaging three or two items of the eight items.

3.1.2.5. Course grade. Students' course grades were obtained from the office of the registrar. Each grade was weighted in the following manner: A+/A = 4.0, A- = 3.7, B+ = 3.3, B = 3.0, B- = 2.7, C+ = 2.3, C = 2.0, C- = 1.7, D+ = 1.3, D = 1.0, D- = 0.7, F = 0.0.

3.1.3. Data analysis

To test the hypothesized model (see Fig. 1), a series of SEM was conducted using LISREL 8.80 (Jöreskog & Sörbom, 2006). The same indices of goodness of fit (i.e., RMSEA, SRMR, NNFI, IFI, and CFI) and rules of thumb were chosen as in Study One. Multi-group SEM was performed to evaluate the invariance of path coefficients across online learning and face-to-face learning groups. First, we tested the equivalence of the measurement model. An initial measurement model with all factor loadings left free to vary was assessed for the two groups simultaneously. Then the factor loadings were constrained to be equal in the two groups, and this constrained model was compared with the freely estimated model. No significant differences in the model fit indices suggested that the constructs have been understood similarly in online and face-to-face learning contexts (Little, 2000). When testing the equivalence of the measurement model, we focused on differences in the fit indices (i.e., SRMR, NNFI, CFI, and IFI) rather than chi-square differences to evaluate the equivalence of the measurement model across the two groups, because the change in chi-square is very sensitive when we apply a large number of constraints (Levesque, Zuehlke, Stanek, & Ryan, 2004; Little, 1997). Second, we tested the invariance of the relations between the constructs across the two groups by constraining the path coefficients to be equal across groups. The chi-square difference test was used to compare the structural models. An initial structural model with all path coefficients left free to vary was assessed as the baseline model. Equality constraints were individually added to each path starting from the one producing the most similar estimates. This procedure was repeated until any constraint would produce a significant change in chi-square when compared with the initial structural model.

3.2. Results and discussion

The descriptive statistics and correlation coefficients between the constructs are presented in Table 6. The fit of the initial unconstrained measurement model was good, χ^2 (184) = 530.42, $p < .001$, NNFI = 0.98, IFI = 0.99, CFI = 0.99, SRMR = 0.03, RMSEA = 0.07, which suggested that the hypothesized model represented a good fit to the data in both online and face-to-face learning contexts. Before we conducted the invariances analyses on the structural model, we tested the measurement equivalence across the two groups in two steps. First, we constrained the factor loadings of need satisfaction and need dissatisfaction to be equal across the two groups. The fit of the constrained model was still good, and the difference in the fit was minimal and not significant, $\Delta\chi^2$ (4) = 8.93, $p > .05$, ΔSRMR < 0.01, ΔRMSEA < 0.01, ΔCFI < 0.01, ΔIFI < 0.01, ΔNNFI < 0.01, suggesting that need satisfaction and need dissatisfaction were understood similarly in the two groups. Second, we constrained all of the factor loadings to be equal. The full constrained measurement model was still good. Compared with the unconstrained model, the difference in fit was minimal, $\Delta\chi^2$ (10) = 29.51, $p < .05$, ΔSRMR < 0.01, ΔRMSEA < 0.01, ΔCFI < 0.01, ΔIFI < 0.01, ΔNNFI < 0.01. The standardized factor loadings are presented in Table 7. The equivalence of the measurement model allows us to further examine the equivalence of the structural model.

To identify the equivalence of the structural model, we constrained the path coefficients in a stepwise fashion (See Table 8). The change in chi-square was used to compare the models. The path coefficients of the unconstrained model suggested that the direct paths from learning climate to perceived knowledge transfer (online: Z = 1.26, $p > .05$; face-to-face: Z = 0.21, $p > .05$), from learning climate to grade (online: Z = 0.15, $p > .05$; face-to-face: Z = 0.82, $p > .05$), from motivation to grade (online: Z = −0.04, $p > .05$; face-to-face: Z = −0.82, $p > .05$) were not significant in both groups. We first put equality constraints on the paths with the smallest regression coefficient differences (< . 05) between the two groups (Model 2). Compared to the unconstrained model, the change of value in chi-square was not significant, $\Delta\chi^2$ (3) = 0.35, $p > .05$, indicating that these three paths were comparable across the two groups. Then, based on a comparison of regression weights in Model 2, another two paths having small regression coefficient differences (< 0.05) between the two groups were chosen to be constrained (Model 3). Compared to the unconstrained model, the change in chi-square was not significant, $\Delta\chi^2$ (5) = 2.11, $p > .05$. Next, based on a comparison of regression weights in Model 3, another two paths with small regression coefficient differences (< 0.10) between the two groups were constrained to be equivalent (Model 4). Compared to the unconstrained model, the change in chi-square was not significant, $\Delta\chi^2$ (7) = 7.14, $p > .05$. We then constrained another two paths with regression coefficient differences less than 0.15 (Model 5) without significantly worsening the model fit, $\Delta\chi^2$ (9) = 11.20, $p > .05$. Then, we constrained the remaining paths one at a time (see Model 6 – Model 9) because they all had relative big differences (> 0.15) in the path coefficients across the two groups. The results showed that constraining the path from need dissatisfaction to grade would not lead to any significant change in chi-square, $\Delta\chi^2$ (10) = 16.53, $p > .05$. However, constraining the other three paths led to significant changes in chi-square, suggesting that the paths from learning climate to need satisfaction, the path from learning climate to need dissatisfaction, and the correlation between need satisfaction and need dissatisfaction were significantly different across online and face-to-face learning contexts. Therefore, Model 6 was chosen as our final model. Fig. 3 presents the standardized coefficients of the hypothesized structural model for online and face-to-face groups.

In both groups, the direct effects of learning climate on students' course grade and perceived knowledge transfer were not significant, suggesting that the effects of learning climate on students' learning outcomes were seen mainly through the mediating roles of basic psychological needs and motivation. Students' motivation was positively associated with need satisfaction and negatively associated with need dissatisfaction. However, need satisfaction and need dissatisfaction demonstrated differing effects on students' learning outcomes. Need satisfaction was positively associated with perceived knowledge transfer but had no significant relation with course grade. Need dissatisfaction was negatively associated with course grade but had no significant relation with perceived knowledge transfer. Our findings revealed that while need satisfaction was related primarily to the perceptions of gains in knowledge transfer, need dissatisfaction was related more closely to students' course grades. Haerens et al. (2015) had found that when students reported that their basic psychological needs were not satisfied, they were also more likely to feel pressured and develop more non-self-determined motivation. In contrast, need satisfaction was related more closely to self-determined motivation. In our study, we found that self-determined motivation, an average of motivation, determined by averaging intrinsic motivation, integrated regulation, identified regulation, was more strongly correlated with need satisfaction ($r = .75$) and perceived knowledge transfer ($r = 0.76$) than need dissatisfaction ($r = -0.12$) and course grade ($r = 0.20$). In contrast, non-self-determined motivation, an average of motivation, determined by averaging introjected regulation, external regulation, and amotivation, was more strongly correlated with need dissatisfaction ($r = 0.61$) and course grade ($r = -0.10$) than need satisfaction ($r = 0.11$) and

Table 7
Study two: Standardized factor loadings for the online and face-to-face learning contexts.

Observed indicators	Factor loadings					Error variance	
	Learning Climate	Need Satisfaction	Need Dissatisfaction	SDI	PKT	Online Learning	Face-to-face Learning
LC1	.91					.19	.17
LC2	.91					.21	.15
LC3	.91					.19	.17
NS1		.90				.24	.16
NS2		.94				.12	.13
NS3		.89				.22	.18
ND1			.83			.29	.34
ND2			.73			.48	.46
ND3			.83			.28	.34
SDI1				.90		.16	.21
SDI2				.95		.11	.11
SDI3				.93		.09	.18
PKT1					.94	.12	.12
PKT2					.94	.12	.10
PKT3					.88	.25	.20

Note: LC = Learning Climate, NS = Need Satisfaction, ND = Need Dissatisfaction, SDI = Self-determination Index, PKT = Perceived Knowledge Transfer.

Table 8
Study two: Invariance analyses of the structural model across online and face-to-face learning contexts.

Model	χ^2	*df*	SRMR	RMSEA	NNFI	CFI	IFI	Δ*df*	Δ χ^2	*p*
Model 1: Unconstrained model	530.43	184	.03	.07	.99	.99	.99			
Model 2 (NS→PKT; LC→Grade; SDI→Grade)	530.78	187	.03	.06	.98	.99	.99	3	0.35	
Model 3 (LC→PKT; SDI→PKT)	532.54	189	.04	.06	.98	.99	.99	5	2.11	
Model 4 (NS→SDI; ND→PKT)	537.57	191	.04	.06	.98	.99	.99	7	7.14	
Model 5 (ND→SDI; NS→Grade)	541.63	193	.05	.06	.98	.99	.99	9	11.20	
Model 6 (ND→Grade)	546.96	194	.05	.06	.98	.99	.99	10	16.53	
Model 7 (LC→NS)	555.81	194	.05	.06	.98	.99	.99	10	25.38	*
Model 8 (correlation between NS and ND)	569.31	194	.05	.07	.98	.99	.99	10	38.88	*
Model 9 (LC→ND)	566.83	194	.07	.07	.98	.99	.99	10	36.40	*

Note: LC = Learning Climate, NS = Need Satisfaction, ND = Need Dissatisfaction, SDI = Self-determination Index, PKT = Perceived Knowledge Transfer.

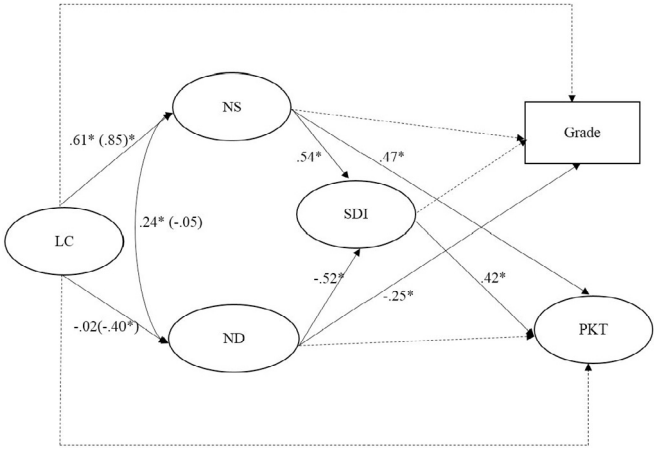

Fig. 3. Structural model across online and face-to-face groups, LC = Learning Climate, NS = Need Satisfaction, ND = Need Dissatisfaction, SDI = Self-determination Index, PKT = Perceived knowledge transfer. Model fit: χ^2 (194) = 546.96, SRMR = 0.05, RMSEA = 0.06, NNFI = 0.98, IFI = 0.99, CFI = 0.99. Numbers in parentheses represent the values for the face-to-face group. Dash lines indicates non-significant estimates in both groups. $^*p < .05$.

perceived knowledge transfer ($r = -0.06$). Therefore, we believe the reason why need satisfaction and need dissatisfaction have differing effects on students' learning outcomes is that they induce different types of motivation.

Regarding the comparison between face-to-face and online environments, three paths were found to vary between the two groups. The relations between learning climate and need satisfaction, learning climate and need dissatisfaction appeared stronger in face-to-face learning contexts. In online learning contexts, the relationship between learning climate and need dissatisfaction was nonsignificant. Moreover, the relation between need satisfaction and dissatisfaction was stronger in online learning contexts. To further understand the differences between the two groups, we examined the mean differences on all constructs included in the model. The results of independent *t*-test (see Table 9) showed that there were significant differences in all constructs. Students in the online learning contexts had lower scores than students in the face-to-face learning contexts in learning climate, need satisfaction, motivation, perceived knowledge transfer, and course grade. Students in the online learning contexts perceived more need dissatisfaction than students in the face-to-face learning contexts. These findings demonstrated that the online courses provide a less motivated environment than the face-to-face courses. More discussion in terms of the different path coefficients between online and face-to-face contexts will be introduced in the next section.

4. General discussion

The purpose of this study was to examine the applicability of BPN in online learning contexts. Though a few successful applications of SDT in online learning have been documented (e.g., Chen & Jang, 2010; Hsu et al., 2019; Rienties et al., 2012; Xie, Debacker, & Ferguson, 2006), none of them has examined the validity of the BPNS in online learning environments. In Study One, we tested the construct validity of BPNS with an online sample. The results of CFA indicated that the three-latent need factors and two-latent method factors model fit the online data adequately; however, one autonomy item and two relatedness items might need revision to fit the online learning contexts. These items were removed from the scale used in Study Two. To examine the concurrent validity of the BPNS in online learning contexts, we examined the associations among learning environment, need satisfaction, need dissatisfaction, self-determined motivation, and learning outcomes with SEM. Furthermore, we compared the SEM models between online and face-to-face learning environments. Our findings indicated that the hypothesized model represented a good fit to both online and face-to-face data. Yet, the relations among learning climate, need satisfaction, and need dissatisfaction were found to vary between the two contexts. This work contributes to the emerging field of online learning by applying SDT to the online learning contexts and comparing the motivation model between online and face-to-face learning contexts.

In the SEM, the need satisfaction and need dissatisfaction constructs were not correlated in the face-to-face learning context, whereas they demonstrated a positive correlation in the online learning context. This is somewhat surprising given studies finding negative relations between need satisfaction and need dissatisfaction (e.g., Costa et al., 2015; Jang et al., 2016). However, positive correlations between satisfaction and dissatisfaction have been identified in other fields when certain types of measures are used. Davern and Cummins (2006) investigated the relation between life satisfaction and life dissatisfaction. They found that

Table 9
Study two: Comparisons between online and face-to-face learning contexts on all constructs.

Construct	Group	*n*	Mean	SD	*t*	Effect Size
Learning Climate	Online	489	4.65	1.66	−6.62*	.42
	Face-to-face	506	5.30	1.44		
Need Satisfaction	Online	462	4.28	1.06	−9.12*	.59
	Face-to-face	487	4.92	1.10		
Need Dissatisfaction	Online	461	3.79	1.16	5.20*	.34
	Face-to-face	487	3.39	1.21		
Self-determination Index	Online	471	3.66	9.29	−4.97*	.32
	Face-to-face	499	7.05	11.88		
Perceived Knowledge Transfer	Online	460	4.55	1.26	−5.70*	.37
	Face-to-face	486	5.05	1.43		
Course Grade	Online	491	3.01	1.03	−7.11*	.45
	Face-to-face	517	3.42	0.78		

when using bipolar scales, life satisfaction was positively correlated with life dissatisfaction. They asserted that participants might be confused by the bipolar scale when rating life dissatisfaction and appear to focus on the satisfaction anchor. This response bias could be driven by positive cognitive biases. In our study, we also used a bipolar scale to assess students' perceptions of need satisfaction and need dissatisfaction. The need dissatisfaction items are mostly written in negative forms. For example, "There is not much opportunity for me to decide for myself how to go about my coursework." It is possible that when students were asked to rate need dissatisfaction, more cognitive effort would be required for them to evaluate the item, and students would experience greater difficulty in rating need dissatisfaction than need satisfaction in our study. Students may overestimate their need dissatisfaction due to the measurement bias, which would affect the correlation between need satisfaction and need dissatisfaction.

It is noteworthy that the unexpected positive correlation was only found in online learning environments, not in face-to-face learning environments. This is likely due to the relatively low quality of teaching perceived by the online learners. We found that compared to the students in the face-to-face courses, students in the online courses reported significantly lower scores in learning climate ($M_{online} = 4.65$; $M_{face\text{-}to\text{-}face} = 5.30$) and need satisfaction ($M_{online} = 4.28$; $M_{face\text{-}to\text{-}face} = 4.92$) and significantly higher scores in need dissatisfaction ($M_{online} = 3.79$; $M_{face\text{-}to\text{-}face} = 3.39$). It may be that when students perceive a low-quality learning environment, they are likely to experience mixed feelings towards their instructors and classes, and therefore tend to suffer more from the measurement bias due to a bipolar scale. Another possibility may be explained by the large physical and psychological distance between instructors and students in online courses. Compared to the face-to-face courses, students in online courses perceive a lack of social presence and interactions (Bowers & Kumar, 2015). In addition, the motivation for students to take an online course may further complicate the ways students perceive the online learning environment. One of the major affordances of online course is the flexibility that allows learners to "attend" the course at their preferred time and location (Reddy et al., 2013). On the other hand, face-to-face class is more instructor-driven with a fixed schedule, and the first day of the class usually set up the course expectations for the entire semester (Haleta, 1996). This might help face-to-face class takers quickly decide to drop from or stay with the course. However, with online courses that relied heavily on asynchronous communication, students form different perception on the expectations for communication and course climate (Mandernach, Gonzales, & Garrett, 2006). It is likely for students who take an online course for its flexibility but gradually realize they do not like certain elements of the course. All these factors combined together, students might be more likely to have inconsistent perceptions of the learning environment and basic psychological needs satisfaction.

Our results also revealed that while need satisfaction was related primarily to the perceptions of gains in perceived knowledge transfer, need dissatisfaction was related more closely to students' course grades. In accordance with our findings, previous researchers have demonstrated that need satisfaction mediated the association between autonomy support and autonomous motivation, whereas need frustration mediated the relations between controlling teaching and controlled motivation (Haerens et al., 2015). Likewise, Jang et al. (2016) found that high school students' engagement was associated with need satisfaction, while disengagement was associated with need frustration. To explain both optimal and non-optimal functioning, SDT researchers distinguished between the bright and dark sides of motivation (e.g., Haerens et al., 2015; Jang et al., 2016; Ryan & Deci, 2007). It is argued that the distinction between the bright and dark sides of motivation is important because both pathways would have differential consequences (Vansteenkiste & Ryan, 2013). Consistent with the literature, we found that need satisfaction was more strongly correlated with self-determined motivation while need dissatisfaction was more strongly correlated with non-self-determined motivation. Therefore, we believe the reason why need satisfaction and need dissatisfaction have differing effects on students' learning outcomes is that they induce different types of motivation. The higher-order thinking skill aligns with the brighter side of motivation, while the course grade is vulnerable to the darker side aspects. Our research adds to this literature by providing evidence in the contexts of both face-to-face and online classrooms in higher education.

There are several limitations of the current research. Mainly, our data were only collected at a large, research institution; thus, it would be important to replicate and generalize our findings to other institutions of higher education with backgrounds dissimilar to the one in the present study. Moreover, we used only correlational results and mostly self-report measures. Future research may use longitudinal and/or other methods to replicate the current findings. Also, self-determined motivation was calculated as a composite score in our models because testing the mediating effects of multiple types of motivation will comprise a complex model, which is beyond the scope of the present study. It will be helpful if future studies could incorporate individual motivation styles into the model and test the distinct antecedents and consequences of each type of motivation. Finally, the current study is limited in terms of the outcome variables that are studied. For example, engagement and well-being are important variables that are predicted by BPN and self-determined motivation, according to SDT. Future studies should consider these and other variables in the SDT model that could be applied to online and face-to-face settings.

5. Conclusion

The results of the current studies extended the application of BPNS into an online learning environment. Our first study provided psychometric evidence for applying BPNS in online learning contexts. The three-latent need factors and two-latent method factors model identified by Sheldon and Hilpert (2012) through face-to-face contexts demonstrated satisfactory fit with the online sample. However, we found one autonomy item and two relatedness items might need modifications to fit the online learning contexts. Our second study demonstrated the concurrent validity of the BPNS in online and face-to-face settings by examining the associations among learning environment, need satisfaction, need dissatisfaction, self-determined motivation, and learning outcomes with SEM. Consistent with previous findings in face-to-face contexts, need satisfaction and need dissatisfaction demonstrated distinctive effects on students' motivation and learning outcomes in online learning contexts. The current research contributes to the developing field of online learning by applying BPNS into the online courses and comparing the motivation model between online and face-to-face learning contexts.

Compliance with Ethical Standards

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent has been waived by the IRB because we used existing data that was collected for institutional research purposes.

Conflicts of interest

The authors declare that they have no conflict of interest.

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