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Reexamining the impact of self-determination theory on learning outcomes in the online learning environment

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Abstract
While various researchers have conducted work supporting the validity of self-determination theory (SDT) in the conventional learning setting, few attempts have been made to explore its application in the online learning context. In a recent study using structural equation modeling (SEM), Chen and Jang (2010) concluded that the SDT-based model was unable to predict the learning outcomes in online programs. After analyzing the model employed in their study, the researchers of the current study identified possible measurement issues and aimed to further examine the SDT-based model after modifications. More than 300 undergraduate students from seven online courses completed the SDT surveys. The results indicated that the satisfaction of basic psychological needs enhanced self-regulated motivation, which was associated with higher perceived knowledge transfer and increased achievement of course objectives in online courses. This study provides empirical evidence for the application of the SDT-based model in the online learning environment.

Keywords Self-determination theory · Motivation · Online learning · Higher education

1 Introduction

Over the past few years, the number of online courses and programs has continued to grow as students, instructors, and school administrators have recognized the benefits of online learning. In 2015, nearly 6 million college students took online courses, which means that more than one in four students took at least one online course (Allen et al.

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2016). As more students are taking online courses, educators and researchers are determining the best practices for online learning and teaching. However, one of the alarming issues surrounding online learning is the relatively high attrition rate (Bawa 2016; Boton and Gregory 2015; Carr 2000; Kizilcec and Halawa 2015). Noncompletion rates as high as 75% to 90% have been reported in previous studies (Breslow et al. 2013; Jordan 2015; Jun 2005; Rochester and Pradel 2008). While various factors contribute to the relatively low student persistence in online learning environments (Croxton 2014; Hart 2012; Lee et al. 2013), motivation, as a potential factor, has drawn increased attention from researchers. Previous studies have pointed out that it is considered a salient factor affecting students' learning outcomes (Brooker et al. 2018; Gunawardena et al. 2010; Lim 2004). Self-determination theory (SDT), one of the well-known motivation theories, has been applied and validated in different domains and settings (see Chen and Jang 2010; Milyavskaya and Koestner 2011; Ryan and Deci 2000). While various researchers have conducted work supporting the validity of SDT in the conventional learning setting, few attempts have been made to explore its application in the online learning context. Therefore, the purpose of this study is to investigate the impacts of SDT on learning outcomes in online learning contexts. The degree to which SDT can be applied and extended to online learning environments becomes increasingly important as the demand for online courses rises and attrition rates remain high.

2 Literature review

With a systematic approach, self-determination theory (SDT) illustrates the interplay of psychological needs, motivation, and well-being for human beings in a variety of contexts. It proposes that the satisfaction of the three needs of autonomy, competence, and relatedness promotes self-determination, which in turn brings about positive outcomes. In other words, a person tends to become self-determined when experiencing a sense of agency (perceiving options in a given situation), capability (being confident to carry out a task), and relatedness (connecting with others), while engaging in daily behaviors.

2.1 SDT in online learning environments

Although applying SDT to traditional face-to-face environments has proven to be a productive undertaking, few attempts have been made to test the application of SDT in online learning contexts. In one of the earliest studies applying SDT to the online learning context, Chen and Jang (2010) did not find a significant relationship between self-determined motivation and students' learning outcomes. They employed structural equation modeling (SEM) to identify the interrelations among contextual support, need satisfaction, motivation, and learning outcomes, and they provided evidence that need satisfaction derived from the support of autonomy and competence in the online learning environment promotes learners' self-determination. However, none of the above factors predicted any of the six learning outcomes they measured. The predicted effect on learning outcomes, which was not supported in their study, is a crucial indicator of effective instruction. Considering the abundance of successful examples of the relationship between self-determined motivation and learning outcomes in the face-to-face classrooms (Deci et al. 1991; Jang et al. 2012; Reeve 2002; Standage et al.

2006; Vallerand et al. 1997; Williams and Deci 1996), the current study aims to reexamine SDT tenets in online learning contexts using SEM.

In the following section, we summarize the main concepts in SDT and describe how we used SEM to test the SDT model and constructs in online courses. In addition, considering Chen and Jang's (2010) study provides a foundation for this line of inquiry, their approach is highlighted and compared with the model employed in this study.

2.2 Three basic needs of SDT

According to SDT, humans seek to satisfy three basic psychological needs: autonomy, competence, and relatedness. In educational contexts, *autonomy* is experienced when an instructor provides students with the ability to make choices within a classroom structure established by the instructor. Autonomy does not mean independence, nor does it indicate unsupervised actions. To satisfy students' need for autonomy, instructors can create opportunities for students to work in their own way and avoid using controlling language like *must* and *should*, which puts undue pressure on students. *Competence*, similar to Bandura's (1986) notion of self-efficacy, refers to students' beliefs that they have mastered content or are able to perform well academically. The satisfaction of the need for competence is enhanced when students are able to see the progress they are making in developing or mastering skills. To fulfill students' need for competence, instructors can provide informational feedback focused on evidence of improvement and mastery and offer progress-enabling hints when students seem stuck. *Relatedness* describes the feeling of being connected and experiencing a sense of belonging. This sense of connection can come from interactions with classmates, professors, or with the learning materials. To enhance the satisfaction of students' need for relatedness, instructors can be responsive to students' questions and comments, be approachable, create opportunities for students to work with one another, and organize course materials to promote learning. In addition, instructors can enhance students' connection with the learning material by emphasizing how it is relevant to students' lives or future careers.

2.3 Impact of SDT on learning outcomes

A considerable body of research has indicated that providing an autonomy-supportive learning environment fosters the satisfaction of students' basic psychological needs, which in turn enhances students' ability to achieve the intended learning outcomes (Deci et al. 1991; Jang et al. 2012; Reeve 2002; Williams and Deci 1996). Levesque-Bristol et al. (2006) developed an integrative model for learning and motivation (IMLM) to explain how student motivation contributes to engagement, metacognition, and knowledge transfer. They suggested that an autonomy-supportive learning environment would satisfy the three basic psychological needs, which would lead to more self-regulated forms of motivation, a greater sense of knowledge transfer, and more positive learning outcomes, such as course grades. In another study, Levesque-Bristol et al. (2010) examined the relationship between the three basic psychological needs and demonstrated that the basic psychological needs of autonomy and relatedness support the development and manifestation of competence. While numerous studies have provided evidence for the paths from enhanced need support, need satisfaction, and

self-regulated motivation to improved learning outcomes in traditional face-to-face classrooms, the SDT model has not been commonly tested in online learning contexts.

2.4 Testing SDT model in online learning

Chen and Jang (2010) used SEM to examine an SDT-based model for online learner motivation (see Fig. 1). In their model, contextual support was hypothesized to be positively associated with basic psychological needs, which positively predicted more self-determined motivation. Moreover, self-determined motivation was hypothesized to result in better learning outcomes. Specifically, Chen and Jang (2010) assessed 6 learning outcomes: hours per week studying, number of hits on the course materials, expected grade, final grade, perceived learning, and course satisfaction. Participants in their study included 267 online students from two online certificate programs. The results of SEM, which was performed separately on the 6 learning outcomes examined, supported the hypothesized relations among contextual support, basic psychological needs, and self-determined motivation. As one of the earliest studies which applied the SDT model in the online learning context, Chen and Jang's (2010) study enriched educators' understanding of online learners' motivation and provided implications for online learning practices.

However, two unexpected findings which could not be fully explained by SDT require further research. First, in Chen and Jang's (2010) study, self-determined motivation failed to predict any of the learning outcomes examined in the general hypothesized model depicted in Fig. 1, while basic need support and satisfaction were associated with some of the learning outcomes. Based on this finding, they suggested that in online learning environments, contextual support and basic psychological needs have more salient effects than self-determined motivation on students' learning outcomes. This conclusion does not fully explain why self-determined motivation has been associated with learning outcomes

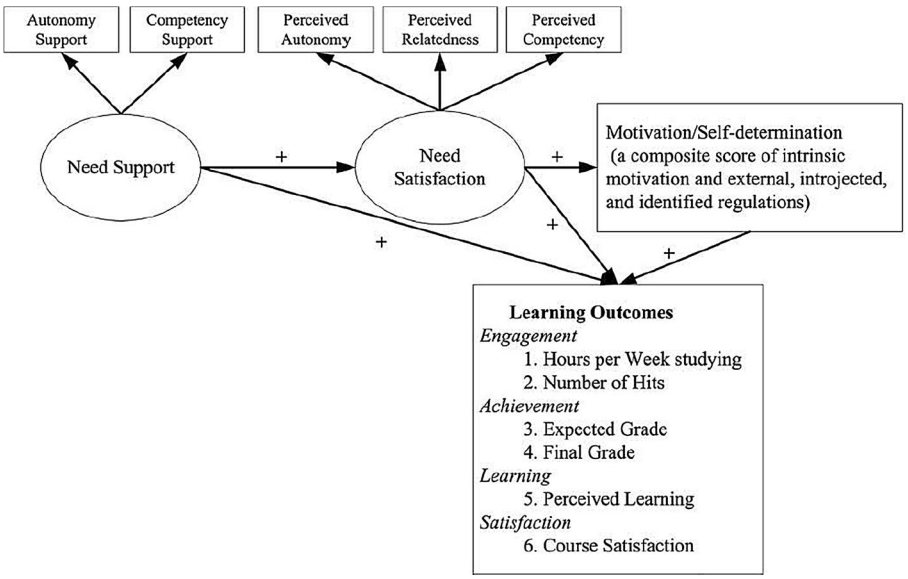

Fig. 1 Hypothesized SDT model in Chen and Jang's (2010) study

in the face-to-face learning context (Standage et al. 2006; Vallerand et al. 1997) but not in the online learning environment. Therefore, this study aimed to explore alternative explanation for the lack of relationship between self-determined motivation and learning outcomes reported by Chen and Jang (2010). As a starting point, the current study considered possible measurement issues in the full model, tested through SEM. In Chen and Jang's (2010) study, self-determined motivation was measured by the Academic Motivation Scale (AMS; Vallerand et al. 1992), which measures five types of motivation including intrinsic motivation, identified regulation, introjected regulation, external regulation, and amotivation. The types of motivation vary based on their underlying level of self-determination, from *intrinsic motivation*, which represents behaviors performed out of pure enjoyment, to *amotivation*, which represents a lack of motivation. *Identified*, *introjected*, and *external regulation* represent types of extrinsic motivation which underlie behaviors performed as a means to an end and also vary their underlying level of self-determination. External regulation underlies behaviors that are performed to obtain a reward or avoid a negative consequence. Introjected regulation underlies behaviors that are performed out of guilt or other internal pressures. Identified regulation underlies behaviors performed because they are perceived to be valuable. In Chen and Jang's (2010) study, an overall level of motivation (i.e., self-determined motivation) was calculated based on the Relative Autonomy Index formula (Grolnick and Ryan 1987). The self-determined motivation construct was treated as an observed variable represented by a rectangle symbol in Chen and Jang's (2010) model. Observed variables, when included in SEM, lead to weaker estimates (Wolf et al. 2013). Therefore, the strength of the relationships with other constructs could be weakened. In contrast, latent variables consist of multiple indicators that define the constructs of interest in a more appropriate and reliable manner, which leads to more stable measurement in SEM. By explicitly defining the measurement features of the construct, latent variables yield better estimates of the true relations between the constructs than observed variables and are preferred when testing a full SEM (Hardre and Reeve 2003; Levesque-Bristol et al. 2010). Therefore, instead of modeling self-determined motivation as an observed variable, as Chen and Jang (2010) did in their study, the current study modeled self-determined motivation as a latent variable.

Second, some of the findings in Chen and Jang's (2010) study were counterintuitive and not consistent with previous studies or the theoretical SDT framework. For example, the direct effects of contextual support on hours of studying per week and number of hits on the course materials were negative; however, the indirect effects of contextual support on those two learning outcomes through basic psychological needs satisfaction were positive. This combination of results for the direct and indirect effects of basic psychological need support and satisfaction on learning outcomes is very surprising and unexpected. This contradicting result indicates that more evidence is needed to confirm the validity of SDT in online learning environments. Moreover, Chen and Jang (2010) combined basic psychological needs into one construct. However, Vlachopoulos and Michailidou (2006) found that a three-factor model was more appropriate for examining the relations between basic psychological needs and other constructs than the one-factor model. Therefore, we employed the three-factor model in this study.

The present study aimed to add to the literature on the impact of motivation factors in online learning environments, and specifically to examine whether the tenets proposed by SDT can be applied in online learning environments. The research questions are as follows:

RQ1: Overall, what are the relationships among various constructs of SDT in online learning environments?
RQ2: More specifically, can satisfaction of three SDT needs lead to better learning outcomes including perceived knowledge transfer, perceived learning gains, and grades?

To answer these questions, we reexamined the impact of SDT on learning outcomes in the online learning environment by modeling self-determined motivation as a latent variable with multiple indicators. We also conceptualized and modeled basic psychological needs as the three separate constructs of autonomy, competence, and relatedness. In addition, based on recent discussions and evidence around the adequate development of perceived competence (Levesque-Bristol et al. 2010; Ryan and Deci 2000), we hypothesized that perceived competence would be a proximal predictor of self-determined motivation, and that autonomy and relatedness would serve as the backdrop to the development of competence.

Our hypotheses are presented in SEM shown in Fig. 2. The autonomy-supportive learning climate (LC) is hypothesized to lead to the satisfaction of students' basic psychological needs. The satisfaction of the basic psychological needs of autonomy and relatedness would foster the development of the need for competence, which would in turn enhance and foster self-determined motivation. Self-determined motivation would then lead to higher perceived knowledge transfer and improved learning outcomes (Levesque-Bristol et al. 2006; Ryan and Deci 2000).

3 Method

3.1 Participants

The analytic dataset includes responses from 330 undergraduate students (200 females and 130 males) from a large research-intensive university in the Midwestern United States. Participants were recruited from courses that had gone through a campus-wide course transformation program. Faculty member engaged in the program to design their

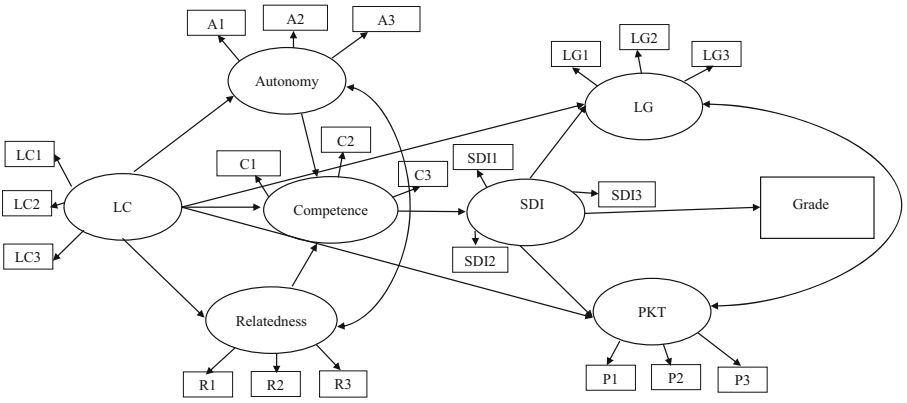

Fig. 2 Hypothesized model. LC = learning climate; A = autonomy; C = competence; R = relatedness; SDI = self-determination index; PKT/P = perceived knowledge transfer, LG = perceived learning gains

courses with a focus on creating student-centered learning environments. Students who enrolled in these courses were contacted via email between the 11th and 13th weeks of the semester and asked to participate in the study. The email included a link to an online survey administered using Qualtrics survey software. To test the applicability of the SDT model in online learning environments, we selected the students who were registered in online courses as the analytic sample. The seven online courses spanned various academic disciplines including agriculture, economics, management, sociology, and statistics. The average age of the participants was 20.19 years old (*SD* = 2.08).

3.2 Measures

3.2.1 Learning climate

Students' perceptions of how the learning climate supported their autonomy were measured using the six-item version of the Learning Climate Questionnaire (LCQ; Williams and Deci 1996). All questions used a 7-point Likert scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). Students indicated the extent to which they agreed with each statement measuring the autonomy supportiveness of the course (or learning environment). Internal consistency for the LCQ in our study was very high (six items; $\alpha = .95$). In order to test the SEM, three LCQ indicators were created by forming three parcels, which consisted of the average of two items together.

3.2.2 Basic psychological needs

Items included in the Basic Psychological Needs at Work Scale (BPNS; Kasser et al. 1992) were modified to reflect an academic environment (Levesque-Bristol et al. 2010) and used to measure perceptions of autonomy (seven items), competence (six items), and relatedness (eight items). The BPNS included 21 statements, all of which used a 7-point Likert scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). Internal consistency was moderately acceptable for the three subscales: autonomy (seven items; $\alpha = .71$), competence (six items; $\alpha = .66$) and relatedness (eight items; $\alpha = .77$). In order to test the SEM model, three indicators were created for each subscale by averaging two or three of the items within each subscale.

3.2.3 Motivation for learning

The Situational Motivation Scale (SIMS; Guay et al. 2000; Levesque-Bristol et al. 2010; Vallerand 1997) was used to measure motivation for participating in the course. The 18-item scale included three items to measure each of the six forms of motivation proposed by SDT (Ryan and Deci 2000): intrinsic motivation, integration, identification, introjection, external motivation, and amotivation. Internal consistency was very good for all six subscales: intrinsic ($\alpha = .96$), integration ($\alpha = .87$), identification ($\alpha = .93$), introjection ($\alpha = .92$), external ($\alpha = .86$) and amotivation ($\alpha = .81$). Using the subscales of the SIMS, three self-determination indices (SDIs; Levesque-Bristol et al. 2010; Vallerand 1997) were calculated by weighting the types of motivation represented by the items in function of their underlying level of self-determination. Those reflecting self-determined forms of

motivation were weighted positively, and those reflecting non-self-determined forms of motivation were weighted negatively. Larger weights were assigned in function of the underlying quality of the motivation (Vallerand 1997). The first indicator was created by pulling the first item of each subscale, and combining them into the first SDI in the following way (See Eqn. 1):

$$\mathrm{SDI}_1 = 3*(\mathrm{IM}_1) + 2*(\mathrm{INTEG}_1) + 1*(\mathrm{IDEN}_1) - 1*(\mathrm{INTRO}_1) - 2*(\mathrm{ER}_1)\ 3*(\mathrm{AM}_1) \quad (1)$$

3.2.4 Perceived knowledge transfer

Knowledge transfer was measured using the eight-item, unidimensional Perceived Knowledge Transfer Scale (PKTS; Levesque-Bristol et al. 2016b). Higher scores on the PKTS indicated that the participants perceived that the information learned would be more likely to be transferred beyond the course (e.g., "I understand how I will use the information learned in this class in my professional life" and "I feel confident in my ability to apply the course material in other classes that I have"). Internal consistency for the PKTS in our study was very high (eight items; α = .97). In order to test the SEM model, three indicators were created for each subscale by forming three parcels that averaged two or three of the items within each subscale.

3.2.5 Student assessment of learning gains

Data on Student Assessment of Learning Gains (SALG) were collected at the end of the semester. Learning gains questions were created based on learning outcomes provided by the instructors and included in the end of semester course evaluations (e.g., "As a result of your work in this class, what gain did you make in the skill of [item provided by the instructor]?"). All questions were evaluated on a 5-point scale (1 = *I gained nothing at all*, 2 = *I gained a little*, 3 = *I gained somewhat*, 4 = *I gained a lot*, and 5 = *I gained a great deal*). Internal consistency for the SALG questions was very high (three items; α = .94).

3.2.6 Students' course grades

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.

3.3 Analysis strategy

The data for the hypothesized model presented in Fig. 2 were analyzed using SEM, which simultaneously examined the structure of the latent constructs (measurement model) as well as the relationships between the constructs (structural model). In the current study, the hypothesized model was used to specify the relationships among variables that were tested using SEM. The results of the SEM analysis indicated the degree to which the hypothesized model fits the data.

In the current study, various indices of goodness of fit for the model were examined including the Non-Normed Fit Index (NNFI), the Incremental Fit Index (IFI), the Comparative Fit Index (CFI), the Standardized Root Mean Square Residual (SRMR), and the Root Mean Square Error of Approximation (RMSEA). The model chi-square (χ^2) was also reported and examined. Theoretically, the chi-square should be nonsignificant for a well-fitting model. However, as chi-square statistics are extremely sensitive to small deviations, especially in large sample sizes (Bentler and Bonnet 1980; Jöreskog and Sörbom 1993), chi-square was not used in this study to determine the overall fit of the model. The NNFI, IFI, and CFI all range from 0 to 1, and a value of .95 is generally recognized as signifying a good fit (Hu and Bentler 1999). The SRMR and RMSEA should be close to 0; SRMR and RMSEA values under .08 are generally considered indicative of an adequate fit, and values under .05 are considered a good fit for a model (Tabachnick and Fidell 2012). The significance tests for regression coefficients were also examined for determining the goodness of fit.

4 Results

Before testing the hypothesized model, descriptive statistics and bivariate correlations were run on all variables. Table 1 presents the degree to which students agreed with the survey items under each variable. Overall, participants perceived a high level of learning gains; a relatively autonomy-supportive learning climate in their courses; moderate-to-high levels of external regulation, perceived knowledge transfer, integration, identification, competence, autonomy, and relatedness; and low levels of intrinsic motivation, introjection, and amotivation. The average course grade was 3.20 (*SD* = 0.94), indicating that approximately 58% of the students earned a score of B or higher.

Table 1 Mean values for each variable by category

Category	Variable	Mean	SD	Min	Max
Learning Outcomes	Learning Gains	3.43	1.01	0	5
	Perceived Knowledge Transfer	4.66	1.50	1	7
	Course Grade	3.20	0.94	0	4
Autonomy-Supportive Learning Climate	Learning Climate	4.96	1.40	1	7
Basic Psychological Needs	Competence	4.30	0.98	1	7
	Autonomy	4.21	0.95	1	7
	Relatedness	4.19	0.89	1	7
Situational Motivation	Intrinsic Motivation	3.58	1.69	1	7
	Integration	4.57	1.41	1	7
	Identification	4.30	1.63	1	7
	Introjection	3.03	1.61	1	7
	External Regulation	4.99	1.46	1	7
	Amotivation	3.04	1.51	1	7
Self-Determined Index	SDI	2.06	11.25	−36	36

The SDI, calculated using the equation presented in the previous section, was 2.06 (*SD* = 11.25), which represented a somewhat self-determined level of motivation.

Table 2 contains the bivariate correlations among the six forms of situational motivation. The pattern of correlations among six forms of motivation generally followed the simplex pattern of motivation proposed by SDT (Ryan and Deci 2000). That is, the self-determined forms of motivation (i.e., intrinsic motivation, integration, and identification) were positively correlated with each other, and non-self-determined forms of motivation were positively correlated with each other. Self-determined forms of motivation tended to be negatively correlated with non-self-determined forms of motivation, although correlations between introjection and the three positive forms of self-determined motivation were positive. In addition, correlations between forms of motivation adjacent on the continuum were generally stronger than for those further apart on the continuum. The confirmation of the simplex pattern in online learning environments suggests that the six forms of motivation fall along a continuum of self-determination and supports the usage of SDI to represent students' overall level of self-determined motivation.

Table 3 presents the bivariate Pearson correlation coefficients among all variables included in our hypothesized model. There were moderate to strong positive correlations among learning climate, autonomy, competence, relatedness, SDI, PKTS, and SALG (ranging from .36 to .74). Although the effect sizes were small, course grade was significantly correlated with learning climate, basic psychological needs, PKTS, and SALG (ranging from .09 to .26). All correlations were significant and in the predicted direction except the one between course grade and SDI, which indicated that our data set is appropriate for using SEM. We then moved on to test our hypothesized model.

The test of the model indicated that it was a good fit to the data, $\chi 2\ (196) = 523.84$, $p < .001$, NNFI = .98, IFI = .98, CFI = .98, SRMR = .05, RMSEA= 0.07. All of the factor loadings in the measurement model were significant at the $p = .001$ level, with associated *t*-values ranging from 10.86 to 36.38. Most of the relationships specified in the structural model were significant at the $p < .05$ level and in the predicted direction, with observed *t*-values ranging from 4.30 to 14.16.

Figure 3 displays the model with the standardized path coefficients. As hypothesized, the direct structural path from learning climate to competence was not significant at the $p = .05$ level. The autonomy supportiveness of the learning climate positively predicted the satisfaction of the basic psychological needs of relatedness ($\beta = .57$, $p <$

Table 2 Bivariate correlations among the six forms of situational motivation

Variable	1	2	3	4	5	6
1. Intrinsic Motivation	1.00					
2. Integration	0.74**	1.00				
3. Identification	0.85**	.84**	1.00			
4. Introjection	0.47**	.40**	.38**	1.00		
5. External Regulation	−0.09	.02	−.04	.24**	1.00	
6. Amotivation	−0.07	−.08	−.20**	.49**	.34**	1.00

**Significant correlation at the $\alpha = .01$ level (two-tailed)

Table 3 Bivariate correlations among variables in the hypothesized model

Variable	1	2	3	4	5	6	7	8
1. LC	1.00							
2. Autonomy	.67**	1.00						
3. Competence	.54**	.69**	1.00					
4. Relatedness	.50**	.55**	.54**	1.00				
5. SDI	.53**	.64**	.74**	.41**	1.00			
6. PKT	.64**	.58**	.61**	.47**	.68**	1.00		
7. LG	.49**	.45**	.48**	.36**	.51**	.59**	1.00	
8. Grade	.09*	.17**	.26**	.13**	.08	.10*	.12*	1.00

LC, learning climate; *SDI*, Self-determination index; *PKT*, perceived Knowledge transfer; *LG*, learning gains
*Significant correlation at the $\alpha = .05$ level (two-tailed). **Significant correlation at the $\alpha = .01$ level (two-tailed)

.001) and autonomy ($\beta = .77$, $p < .001$), which, in turn, were associated with perceived competence. Unexpectedly, the path from relatedness to competence was small and was not significant ($\beta = .05$, $p > .05$).

Table 4 shows a comparison between the results of Chen and Jang's (2010) work and the current study. In contrast to Chen and Jang's (2010) study, this study established the complete path from learning climate (contextual support), need satisfaction, and self-determined motivation to three target learning outcomes, including perceived knowledge transfer, learning gains, and course grades. We found a much stronger association between basic psychological needs and SDI, through the satisfaction of the need for competence. In addition, we examined autonomy, competence, and relatedness separately, which allowed us to explore the relations within the three basic psychological needs. More specifically, perceived competence was found to be the most proximal predictor of students' self-determined motivation. The satisfaction of the needs for autonomy and relatedness contributed only indirectly to self-determined motivation through perceived competence. This finding was in line with what Levesque-Bristol et al.'s (2010) conclusion that competence had a dominant

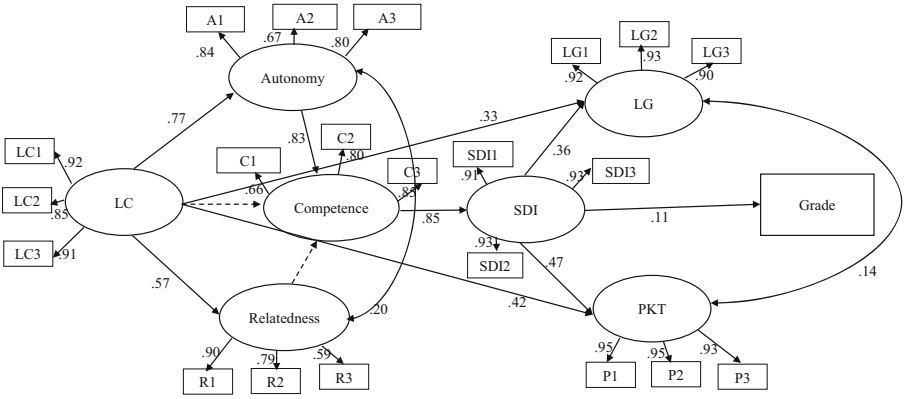

Fig. 3 Final model with standardized path coefficients. Lines in dash represent non-significant paths. All estimates were significant at the $p < .05$ level

Table 4 Results in comparison with Chen and Jang's (2010) study

Path relations	Chen and Jang's (2010) study	The present study
Contextual Support to BPNS	0.85–0.87***	LC to Autonomy: 0.77*** LC to Relatedness: 0.57*** LC to Competence: 0.64***
Within BPNS	Not investigated	Autonomy to Competence: 0.83*** Relatedness to Competence: 0.05 Autonomy to/from Relatedness: 0.20***
BPNS to SDI	0.14–0.15*	Competence to SDI: 0.85***
SDI to Learning Outcomes	SDI to Numbers of Hits: 0.09 SDI to Hours of Studying: 0.03 SDI to Expected Grade: 0.01 SDI to Final Grade: 0.03 SDI to Perceived Learning: 0.06 SDI to Course Satisfaction: 0.01	SDI to Course Grade: 0.11* SDI to PKT: 0.47*** SDI to LG: 0.36***

BPNS, basic psychological needs; *LC*, learning climate; *SDI*, self-determination index; *PKT*, perceived knowledge transfer; *LG*, learning gains

*Significant correlation at the $\alpha = .05$ level (two-tailed). **Significant correlation at the $\alpha = .01$ level (two-tailed). ***Significant correlation at the $\alpha = .001$ level (two-tailed)

contribution to students' self-determined motivation and it could be enhanced by satisfying the needs for autonomy and relatedness. Overall, the results supported the hypothesized model and provided evidence for the application of SDT in online learning environments, as for the first time the learning outcomes were found to be associated with basic psychological need satisfaction and motivation.

5 Discussion

Our first research question explored the relationship among various constructs of Self-Determination Theory (SDT) in online learning environments. To address this question, we tested an SDT-based model, which was conceptualized in the Integrative Model of Learning and Motivation (IMLM), with a sample of students taking college-level online courses. Based on SDT and the IMLM, the relationships proposed among learning climate, basic psychological needs, motivation, and learning outcomes, that are commonly found in traditional face-to-face learning environments (Levesque-Bristol et al. 2016a, b), were generally supported in the online learning environment.

Student-centered online courses, which fulfilled students' basic psychological needs, fostered students' self-determined motivation and achievement of learning outcomes. Generally, the paths from learning climate, to self-determined motivation, to learning gains, perceived knowledge transfer, and course grade were significant. Specifically, basic psychological needs mediated the relationship between learning climate and self-determined motivation. The strongest path to self-determined motivation was from learning climate to autonomy and then to competence, which in turn predicted self-determined motivation. Recent findings in face-to-face learning environments suggested that competence is the most proximal predictor of self-determined motivation and that it is better developed in environments that are autonomy supportive (Levesque-

Bristol et al. 2010). Our findings support this argument and extend the literature by examining these relationships in the online learning environment. The most surprising aspect of our findings is in the non-significant relation between relatedness and competence. A possible explanation for this might be that relatedness is less important in online learning contexts, so it contributes little to students' perceptions of competence. However, weaker relationships between relatedness and other basic needs and students' motivation have also been found in previous studies of face-to-face learning contexts (Cheon et al. 2012; Levesque-Bristol et al. 2010). Another possible explanation for the unexpected result could be the potential lack of content validity of the BPNS in online learning contexts. Although the BPNS has been widely used to assess college students' basic psychological needs in face-to-face learning environments (Johnston and Finney 2010; Levesque-Bristol et al. 2010; Sheldon and Hilpert 2012), few studies (Chen and Jang 2010, and the present study) have examined the application of the scale within online learning contexts. The items developed to measure relatedness in face-to-face contexts may not all be applicable in online contexts.

Our second research question focused on the impact of self-determined motivation on learning outcomes in an online learning environment. Our analysis confirmed a positive link, which was not found in Chen and Jang's (2010) study, in which an SDT-based SEM was also performed. They reported that the path from contextual support to need satisfaction and then to self-determined motivation was significant, which supported SDT. However, self-determined motivation failed to predict any of the learning outcomes, including engagement, achievement, perceived learning, and course satisfaction, which contradicted SDT. In their study, the self-determined motivation variable was considered as an observed variable. Technically, self-determined motivation is not directly observed but rather is inferred from students' responses on the items in Academic Motivation Scale (AMS), therefore, it should be considered as a latent variable. In addition, SEM is more appropriate when dealing with latent variables (Card and Little 2007; Dimitrov 2006), as it represents latent variables without the presence of measurement errors. Viewing self-determined motivation as an observed variable might reduce the reliability of capturing the construct. The measurement errors of self-determined motivation were not taken into account.

In the current study, we considered self-determined motivation as a latent variable and found significant relations between self-determined motivation and learning gains, course grade, and perceived knowledge transfer. Moreover, Chen and Jang (2010) found that the direct effects of contextual support on some learning outcomes were negative and suggested that ineffective support would lead to adverse results. However, in our study, the direct relations between autonomy-supportive learning climate and students' learning outcomes were positive, which are in line with most SDT studies in face-to-face contexts (Standage et al. 2006; Vallerand et al. 1997). Our findings further support the idea of applying SDT to online learning contexts and provide an alternative explanation to Chen and Jang's (2010) findings.

6 Conclusion and recommendations

In responding to the call that more studies need to be conducted to better understand the role of self-determination in online learning contexts (Chen 2007; Chen and Jang 2010; Giesbers et al. 2013), we tested the SDT model with data collected from semester-long

online courses in higher education. The result was a breakthrough for extending the application of the SDT model into the online learning environments, because it established the complete path from learning climate, need satisfaction, and motivation, to learning outcomes. In other words, satisfying the three basic needs proposed in SDT can promote learning outcomes in online learning contexts. The well-studied and supported path of success in traditional face-to-face classrooms can be reproduced in online courses as well.

This result should prompt researchers and practitioners to think differently about the role students and instructors play in online learning environments. While previous studies tend to ascribe successful learning outcomes to online learners' ability to manage their own learning, this study provides an opportunity to refocus the conversation on the importance of an autonomy supportive learning environment for student success, in face-to-face as well as online learning environments. The current study highlights the importance of basic psychological need satisfaction and self-determined motivation through the creation of online learning environments which can support learners through the lens of SDT. A picture of leaving learners to "sink or swim" seemed to be portrayed in the online learning literature, which is troubling considering the high attrition rates in online courses. However, our validation of the SDT model in online contexts indicates that learners should not be solely responsible for the attainment of learning outcomes.

Effective online pedagogy that fulfills the three universal SDT needs will help learners succeed by enhancing their level of motivation. Although the general SDT model was supported in the current study, when examining online learning environments researchers should continue to explore possible distinctions and ways of supporting online learners. This is warranted because of apparent differences in the dynamics of face-to-face and online learning environments.

Due to the quantitative nature of the current study, it was not clear how the instructors facilitated learning, what instructional strategies were deployed, and how materials were structured in each of the seven online courses studied. A follow-up study that utilizes content analysis of the online courses and interviews with instructors and students would provide a clearer picture of the components of a student-centered online course, as well as effective online teaching strategies. In addition to filling the gap in previous research, the positive results of this study open the door for researchers with similar interest to explore SDT in online learning environments.

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