Research in Higher Education (2020) 61:1002–1026
https://doi.org/10.1007/s11162-020-09592-x

Multilevel Factors Affecting College Students' Perceived Knowledge Transferability: From the Perspective of Self-Determination Theory

Cong Wang[1,2] · Ying Zhang[3] · Jennifer D. Moss[4] · Emily M. Bonem[1] · Chantal Levesque-Bristol[1]

Received: 26 January 2019 / Published online: 2 April 2020

Abstract
Promoting students' ability to transfer or apply their knowledge and skills to real-life situations is critical in higher education. The current study was designed to test the likelihood that the constructs based on self-determination theory (SDT) framework help understand college students' perceived knowledge transferability. A total of 3783 undergraduates from 301 classes participated in this study. The results of a series of multilevel modeling analyses indicated that (a) competence satisfaction and identification were the most salient factors influencing students' perceived knowledge transferability; (b) the SDT-related variables together explained 64.2% of the between-student variance in perceived knowledge transferability; (c) after controlling for student-level covariates and SDT-related variables, 7.9% of the variance in perceived knowledge transferability was caused by between-class differences, and 19.6% of it could be explained by course fields and course levels. Our results, which provide evidence of multilevel factors influencing college students' perceived knowledge transferability, have implications for promoting transfer in higher education.

Keywords Perceived knowledge transferability · Multilevel modeling · Self-determination theory · Higher education · Motivation

An important goal of higher education is to prepare graduates with the knowledge and skills for success in the workforce (Wang et al. 2019b). Promoting knowledge application has become one of the primary responsibilities of higher education in the United States (Higher Learning Commission 2019). Knowledge transferability refers to the capability of applying knowledge and skills that have been learned in school into a new situation,

✉ Cong Wang
wangcong525@hotmail.com

[1] Center for Instructional Excellence, Purdue University, West Lafayette, IN, USA

[2] Yale University, New Haven, CT, USA

[3] Syracuse University, Syracuse, NY, USA

[4] Emporia State University, Emporia, KS, USA

which is considered an important indicator of educational success (Bransford and Schwartz 1999). Additionally, a majority of employers value academic programs which support knowledge transferability (Hart Research Associates 2006). Many employers expect students to be able to apply what they learned in college immediately after graduation. Identifying factors which influence college students' confidence in their ability to transfer their knowledge from one setting to another would be valuable for institutions interested in developing interventions to foster academic success and transition to work. So far, most studies of learning transfer focus on cognitive precursors, such as surface similarity, deep structure, prior knowledge, cognitive load, and task difficulty (Billing 2007; Day and Goldstone 2012). These studies overlook motivational influences that account for much of people's attitudes and behaviors (Belenky and Nokes-Malach 2012; Burke and Hutchins 2007; Perkins and Salomon 2012). Here, we use self-determination theory (SDT; Deci and Ryan 1985; Ryan and Deci 2017) as a framework for understanding how students' perceived knowledge transferability may be influenced by motivational factors.

SDT is a comprehensive theory of human motivation that examines how social contexts and individual differences facilitate different types of motivation, which in turn, foster learning, performance, positive experiences, and well-being (Deci and Ryan 2015). SDT has been supported with wide applications and research for over four decades (Ryan and Deci 2017). Self-determined motivation, within the educational context, underlies behaviors that are performed by people because they are found to be interesting (intrinsic motivation), consistent with their integrated beliefs (integration), or values (identification), rather than for externally referenced reasons (Ryan and Deci 2017). Self-determined motivation has been recognized as a critical predictor of college students' perceived knowledge transferability (Hsu et al. 2019; Levesque-Bristol et al. 2020; Wang et al. 2019a). However, the focuses of those studies were to confirm the SDT model, not to examine the factors influencing perceived knowledge transferability; therefore, the relationships between SDT-related variables and students' perceived knowledge transferability were not fully examined.

The current study contributes to the existing literature in several ways. This is the first study to examine the direct associations between perceived knowledge transferability and a variety of SDT-related variables, such as autonomy-supportive learning climate, basic psychological needs, and situational motivation. It is critical to understand which variable has the highest power in predicting[1] college students' perceived knowledge transferability so that educational researchers and practitioners can design effective interventions. Second, this study was conducted across a wide variety of educational programs with a large sample. Compared to other studies with small samples within particular contexts, such as psychology (e.g., Levesque-Bristol et al. 2010; Young-Jones et al. 2014), the findings of the current study are more generalizable in terms of academic disciplines and are more informative to educational practice and policy. Moreover, by using a multilevel modeling approach, we were able to take both class- and student-level differences into account and examine influential factors at each level. The hierarchical structure of educational data has often been overlooked by previous research using structural equation modeling (e.g., Hsu et al. 2019; Wang et al. 2019a). In addition to individual-level SDT-related variables (e.g., perceptions of autonomy-supportive learning climate, competence satisfaction, and intrinsic motivation), we took a first step in exploring the impact of four class-level characterstics

[1] In the current study, we used predict, predictor, prediction, or predicting to describe the associations between the independent variables and the dependent variable. These terms do not suggest causation.

that have been suggested to be relevant to college students' perceived knowledge tranferability, including group work (e.g., Sears and Pai 2012), problem-based learning (e.g., Wang et al. 2019b), course level (e.g., Chi and VanLehn 2012), and course field (e.g., Xu 2013). Differences between classes and the extent to which class-level factors can influence the magnitude of individual perceived knowledge transferability may have implications for class-wide intervention efforts.

Perceived Knowledge Transferability

Transfer refers to the direct replication and application of prior knowledge and skills in a new situation (Belenky and Nokes-Malach 2012; Bransford and Schwartz 1999) and the ability to learn in knowledge-rich environments (Bransford and Schwartz 1999). It is usually assessed in terms of how well and how fast the participants complete the transfer tasks; however, researchers cannot usually collect data from a large sample in this way because assessing actual transfer performance costs researchers' laborious hours. In addition, transfer tasks vary across disciplines when measuring knowledge transfer and thus are not practical when conducting research across multiple disciplines. In order to gain a general understanding of factors associated with transfer in a variety of educational programs, we studied college students' perceived knowledge transferability instead of their actual knowledge transfer. Previous research suggests that college students' self-reports of learning can provide accurate and appropriate data regarding their experiences (Fedesco et al. 2019; Zilvinskis et al. 2017). Because college students have had substantial learning experiences, we believe their perceptions provide valuable information about their knowledge transferability. Recent studies have shown that college students' perceived knowledge transferability is positively correlated to their perceived learning and course grades (Hsu et al. 2019; Wang et al. 2019a). In the current study, *perceived knowledge transferability* refers to the extent to which students perceive the connections between their initial learning and a new situation and feel confident in their ability to apply this knowledge to the new situation. Although the connection between motivation and knowledge transferability makes intuitive sense, this link has not been well explored (Nokes and Belenky 2011). In the current study, we used SDT as a framework for understanding how college students' perceived knowledge transferability may be influenced by motivational constructs.

Self-determination Theory

SDT is a humanistic motivational theory, suggesting that humans thrive in environments that satisfy the three basic psychological needs: autonomy, competence, and relatedness (Deci and Ryan 1985; Ryan and Deci 2017). *Autonomy* refers to the volition and the desire to organize and behave in a way that is consistent with one's sense of self; *competence* is the ability to effectively accomplish tasks or master certain skills; and *relatedness* denotes feelings of connection and a sense of belonging. Generally speaking, factors in the social environment that satisfy individuals' needs for autonomy, competence, and relatedness will facilitate self-determined types of motivation and behaviors (Ryan and Deci 2017).

Individuals engage in behaviors for a variety of reasons, which can be differentiated based on their underlying levels of self-determination (Ryan and Deci 2017). The prototype of self-determined motivation is *intrinsic motivation*, which refers to the state of

engaging in an activity for enjoyment (Deci and Ryan 2008). SDT distinguishes among different types of extrinsic motivation along the continuum of self-determination (Deci et al. 1991). *Integration* is the most self-determined form of extrinsic motivation (Deci and Ryan 2008), which occurs when the extrinsic motivation aligns with other aspects of individuals' values, goals, needs, and beliefs (Schreiber 2016). *Identification* refers to a type of extrinsic motivation that people exhibit because they identify with the personal value and importance of the behavior (Ryan and Deci 2017). *Introjection* is a form of extrinsic motivation which underlies behaviors that are performed by people engaging in activities to avoid guilt and shame or to please others (Ryan and Deci 2017). This form of motivation is not fully self-determined because the regulation of the behavior is not fully integrated into a person's holistic self-representation. People with *external regulation*, the least self-determined form of externally regulated motivation, take action to obtain rewards or avoid punishments (Ryan and Deci 2017). Finally, *amotivation* denotes an absence of motivation or regulation. Amotivated individuals have low self-efficacies and see no value in completing tasks. SDT researchers have asserted that intrinsic motivation, integration, and identification are self-determined types of motivation; by contrast introjection, extrinsic regulation, and amotivation are nonself-determined types of motivation (Ryan and Deci 2017).

Motivation and Knowledge Transfer

Although there is not much direct evidence, studies on the effects of intrinsic motivation and extrinsic motivation may shed some light on the relationship between self-determined motivation and knowledge transfer. In Tracey et al. (1995) study with 505 adults, both extrinsic reinforcement and intrinsic reinforcement showed significant positive correlations with transfer behavior. Taylor et al. (2005) found that transfer was greatest when extrinsic components (e.g., rewards and sanctions) were involved in trainees' work environments. Burke and Hutchins (2007) reviewed the literature on training transfer and pointed out that both extrinsic and intrinsic factors influence transfer, and findings appear to favor intrinsic factors. Overall, the findings of the effects of intrinsic and extrinsic motivation on transfer are mixed (Burke and Hutchins 2007); however, in all of these studies, motivation is viewed as a dichotomy. This can be problematic because people can still perceive autonomy even when enacting extrinsically motivated behaviors (Deci and Ryan 2000). As previously stated, integration and identification are extrinsic motivation; however, they are self-determined as well. Viewing motivation in terms of a continuum of self-determination instead of a dichotomy, therefore, allows for a more fine grained analysis, and adds explanatory power.

Evidence from transfer literature on the effects of other motivational constructs might have implications for self-determined motivation as well. Recently, researchers started to link transfer with motivational factors, such as achievement goals (e.g., Belenky and Nokes-Malach 2012) and subjective task values (e.g., Axtell et al. 1997). Consistent with other studies on the effects of achievement goals on learning, undergraduates with mastery goals performed better on a transfer task than the ones with performance goals (Belenky and Nokes-Malach 2012; Bereby-Meyer et al. 2004). Performance-oriented students may implement strategies focused on mechanically memorizing material in order to gain high grades, while mastery-oriented students may use more deep processing approaches to further their understanding. Adopting deep learning strategies could help the students form

mental representations of the information they learned, which would further promote transferability.

Transfer is also influenced by subjective task values (Burke and Hutchins 2007). Axtell et al. (1997) found that adult trainees who perceived training as relevant had higher levels of skill transfer. Lim and Morris (2006) studied 181 Korean employees and found that people's immediate learning needs significantly affected their perceived learning transfer. Perceived value may affect transfer through engagement and transfer propensity. Taken together, previous research on motivation and transfer suggests that self-determined types of motivation, which are associated with constructive and reflective cognitive processes and high-quality engagement (e.g., Jang 2008), can promote knowledge transferability.

Self-determination Theory and Transfer

Based on SDT, an autonomy-supportive learning climate could satisfy students' basic psychological needs for autonomy, competence, and relatedness, which in turn promote more self-determined types of motivation and better learning outcomes (Deci et al. 1991; Jang 2008; Reeve et al. 2002; Williams and Deci 1996). As noted above, however, empirical evidence on SDT and knowledge transferability is quite limited. Levesque-Bristol et al. (2006) took a first step in incorporating knowledge transfer into an integrative model for learning and motivation (IMLM) guided by SDT. According to this model, knowledge transfer is more likely if students endorsed more self-determined forms of motivation.

Several recent studies testing the IMLM with undergraduate participants demonstrated the positive relationship between self-determined motivation and college students' perceived knowledge transferability (Hsu et al. 2019; Levesque-Bristol et al. 2020; Wang et al. 2019a); however, self-determined motivation was calculated as a composite score in those models. No evidence has shown how individual motivation styles influence students' perceived knowledge transferability. Ryan and Deci (2017) pointed out that each type of motivation has distinct antecedents and features. For example, in the educational domain, identification has been recognized as a critical factor of students' academic engagement, persistence in school, and successful adaption (Koestner and Losier 2002). In a study with 60 undergraduates, Burton et al. (2006) found that identification primarily influenced academic performance, while intrinsic motivation predicted psychological well-being. These studies seem to indicate that there is compelling need to disentangle the potentially unique and complementary roles of different types of motivation, which is in line with Vansteenkiste et al.'s (2018) suggestion. To identify the sources of variance influencing college students' perceived knowledge transferability, investigating the unique predicting effect of each type of motivation is necessary.

In addition, the focus of previous studies (Hsu et al. 2019; Levesque-Bristol et al. 2020; Wang et al. 2019a) was to examine the SDT; the relationships between SDT-related variables and college students' perceived knowledge transferability were not completely examined. For example, the direct associations between basic psychological needs and perceived knowledge transferability were missing. Consistent with the presumed differential role of various types of motivation, classic work in SDT (e.g., Deci and Ryan 2000; Ryan and Deci 2017) has found that some needs are more salient in certain situations. Furthermore, previous researchers primarily used structural equation modeling to examine the relationships among variables and overlooked the hierarchical structure of the data. Scholars have generally agreed that, in many educational studies, the observations are not independent. For

example, students are nested within classes, and classes are nested within schools. Thus, we used the multilevel modeling approach to examine the direct associations between college students' perceived knowledge transferability and a variety of SDT-related variables, including autonomy-supportive learning climate, autonomy satisfaction, competence satisfaction, relatedness satisfaction, and different types of motivation including intrinsic motivation, integration, identification, introjection, external regulation, and amotivation.

Class-Level Factors

The current study examines four class-level characteristics that were suggested to be relevant to college students' perceived knowledge transferability: group work, problem-based learning (PBL), course level, and course field. Previous studies have demonstrated that college students' transferability benefits from high-impact practices (Kuh 2008), such as studying in small groups (e.g., Pai et al. 2015; Sears and Pai 2012) and engagement in PBL activities (e.g., Wang et al. 2019b). Course level is also associated with student learning experiences (Crawford and MacLeod 1990). In the U. S. higher education system, most introductory or fundamental courses are listed as 100-level courses and are designed mainly for freshmen. In contrast, a large part of specialized courses are listed as 200- or 300-level and offered to sophomores and juniors. College students' perceived knowledge transferability might vary across different course levels. Students taking higher-level courses might be more likely to learn detailed and specific knowledge or skills from those courses because those courses tend to concentrate on a specific area of a subject instead of a general domain. In addition, students taking higher-level courses are likely to have greater content mastery, so they should be more likely to perceive the possibilities of applying the knowledge in the future (e.g., Chi and VanLehn 2012). We also considered if college students' perceived knowledge transferability would differ between STEM courses and non-STEM courses. Xu (2013) found that college students majoring in STEM fields were more likely to find jobs aligned with their majors than students majoring in non-STEM fields; however, the differences between STEM and non-STEM on the course level have received scant attention. Therefore, this study looked into the effects of these four class-level factors to see if they may influence college students' perceived knowledge transferability in addition to the individual-level factors.

The Current Study

The goal of the current study was to use SDT as a framework to explore the motivational factors influencing college students' perceived knowledge transferability and to enrich the empirical studies on SDT in the area of education. In line with previous work (Hsu et al. 2019; Levesque-Bristol et al. 2020; Wang et al. 2019a), we adopted the SDT framework to investigate the motivational factors influencing college students' perceived knowledge transferability, but we increased emphasis on investigating which motivational factors had strong predictive effects. Specifically, we examined the relations between perceived knowledge transferability and a variety of SDT-related variables, including perceptions of an autonomy-supportive learning climate, autonomy satisfaction, competence satisfaction, relatedness satisfaction, and six types of situational motivation, with a large diverse sample from varied academic disciplines. We used the multilevel modeling approach, which is a

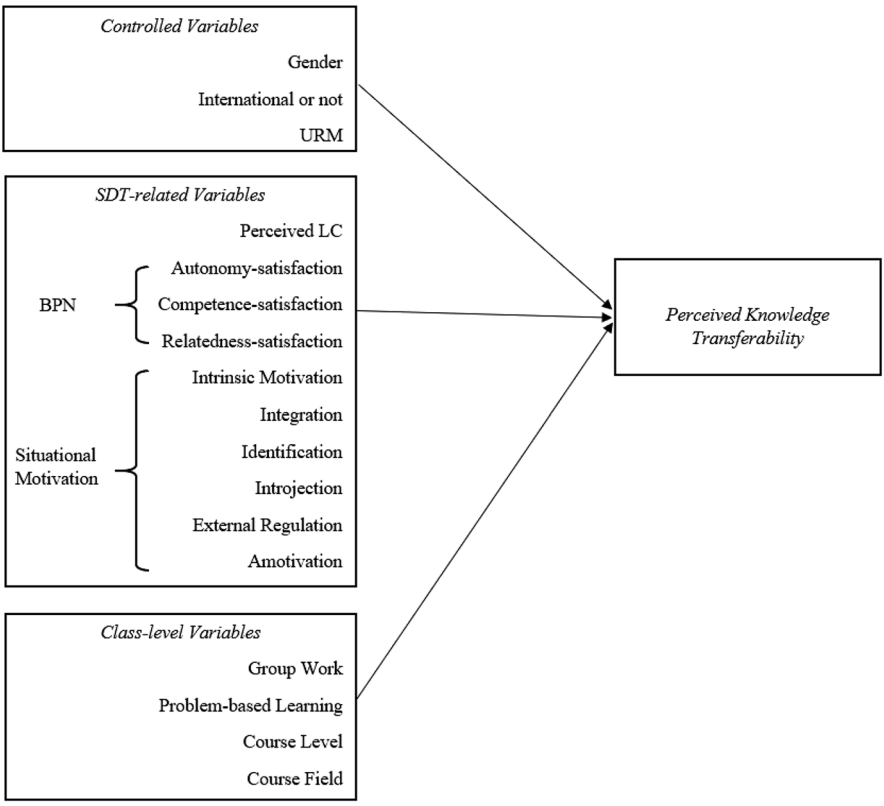

Fig. 1 The conceptual model of the study. *BPN* basic psychological needs, *LC* autonomy-supportive learning climate, *URM* underrepresented minority

more advanced method than ordinary least square regression, to analyze the hierarchical data (i.e., students nested in classes). One advantage of multilevel modeling approach is that it can examine influential factors at each level. Higher-level factors (e.g., class-level) may help explain lower-level (e.g., student-level) differences (Tabachnick and Fidell 2007). To have a better understanding of the factors that influence college students' perceived knowledge transferability, we also sought to ascertain the likelihood that class characteristics (group work, problem-based learning, course level, and course field) were related to college students' perceived knowledge transferability. The extent to which classes varied in terms of college students' perceived knowledge transferability and the effects of classes on individual perceived knowledge transferability both have important implications for promoting teaching and learning in higher education.

The conceptual model displayed in Fig. 1 guided our research questions. First, are SDT-related constructs associated with college students' perceived knowledge transferability? Based on the SDT literature and prior empirical evidence (Hsu et al. 2019; Levesque-Bristol et al. 2020; Wang et al. 2019a), we hypothesized that after taking individual-level controlled variables into account, college students' perceived knowledge transferability would be positively associated with their perceptions of autonomy-supportive learning climate, basic psychological needs satisfaction, and self-determined types of motivation (i.e.,

intrinsic motivation, integration, and identification) and negatively associated with nonself-determined types of motivation (i.e., introjection, external regulation, and amotivation). Furthermore, we are interested in understanding which SDT-related variables are more effective in predicting college students' perceived knowledge transferability while controlling for others. No hypothesis was forumulated for this question due to insufficient prior research.

Second, does college students' perceived knowledge transferability vary across classes? If so, are they influenced by class-level variables? We hypothesized that there were significant between-class differences in college students' perceived knowledge transferability. Moreover, we hypothesized that group work and problem-based learning were positively associated with college students' perceived knowledge transferability. Students taking higher-level courses would perceive more knowledge transferability than students taking lower-level courses. Course field (STEM or non-STEM) would be a significant factor associated with college students' perceived knowledge transferability.

Method

Participants

The participants were from a leading public research university in the Midwestern United States. The university offers more than 200 undergraduate programs, more than 80 graduate programs and is well-known for its competitive programs in STEM fields. Participants were recruited from courses that had been a part of a campus-wide course transformation program. Guided by the framework of SDT, faculty members who participated in the program were encouraged and assisted to redesign their courses to focus on creating autonomy-supportive learning environments. The faculty participated in weekly course transformation workshops for 13 weeks to reflect on their teaching practices and how they could apply research-based, pedagogically sound teaching approaches to their course design. Rather than recommending a single approach to redesigning the courses, this program focused on helping faculty provide students with autonomy-supportive learning environments to satisfy students' basic psychological needs, which has been demonstrated to improve student outcomes (Bonem et al. 2019). Consequently, the teaching models and tools that each faculty member adopted varied depending on their individual needs, providing the faculty themselves with autonomy in their redesign choices. A full description of the program can be found in Levesque-Bristol et al. (2019a, b) recent work.

Students who enrolled in these courses were contacted at the end of the semester via emails and asked to participate in an online survey administered with Qualtrics survey software (Qualtrics 2015). Out of the 47021 student surveys sent over three semesters, 8510 responses were received, for a response rate of 18.1%. Some students provided multiple responses because they were enrolled in more than one transformed course. We randomly selected one response for those students and ended up with 6461 (6337 undergraduates) unique responses from 693 course sections. Faculty members who participated in the course transformation program were also contacted at the end of the semester and asked to respond to a survey regarding their course redesign approaches. A total of 301 course

sections had course transformation data available.[2] Therefore, the final analytic sample includes 3783 undergraduate students (48.7% females). The average age of participants was 19.84 years (*SD* 2.31), most of whom self-identified as White ($n=2565$; 67.8%), followed by International ($n=714$; 18.9%), Asian ($n=151$; 4.0%), Hispanic ($n=138$; 3.7%), and African American ($n=74$; 2.0%). Of the participants, 7.0% were identified as URM. Half the participants ($n=1846$; 48.8%) were enrolled in STEM courses. Approximately 43.8% ($n=1657$) of students were enrolled in 100-level courses, 39.9% ($n=1,510$) students were enrolled in 200-level courses; and 16.3% ($n=616$), in 300-level courses.

Measures

Four scales were included to assess college students' perceived knowledge transferability, perceived learning climate, basic psychological needs, and motivation. These items were rated on a 7-point Likert scale ranging 1 (*strongly disagree*) to 7 (*strongly agree*). See Appendix for the full versions of these scales.

Perceived Knowledge Transferability Scale (PKTS)

Perceived knowledge transferability was measured using the eight-item, unidimensional PKTS (Levesque-Bristol et al. 2020). Higher scores on the PKTS indicate that the participants perceived the information learned as more likely to be transferable beyond the course. Example items include the following: "I feel confident in my ability to apply the course material in other classes that I have" and "I feel as if the material covered in this course is relevant to my future career." In this sample, the internal consistency for the PKTS was excellent (Cronbach's $\alpha=0.97$). This variable was measured at the student-level.

Perceptions of Autonomy-Supportive Learning Climate

Students' perceptions of autonomy-supportive learning climate were measured using the six-item version of the unidimensional Learning Climate Questionnaire (LCQ) (Williams and Deci 1996). Higher scores on the LCQ reflect a more student-centered, autonomy-supportive environment. Example items include the following: "I feel my instructor provides me with choices and options," "I feel understood by my instructor," and "My instructor conveyed confidence in my ability to do well in the course." Validity and internal consistency for the LCQ have been demonstrated in previous research (Levesque-Bristol et al. 2010; Williams and Deci 1996), and internal consistency was excellent in the current study (Cronbach's $\alpha=0.95$). This variable was measured at the student-level.

Basic Psychological Needs

The 21-item Basic Psychological Needs Satisfaction Scale (BPNS) (Gagné 2003) assesses the extent to which employees perceive their needs for autonomy, competence, and relatedness are met. The scale was adapted and modified for an educational setting. The BPNS scale contains three subscales: autonomy (seven items), competence (six items), and

[2] In the present study, the terms course sections and classes are used interchangeably. A course may include multiple sections/classes.

relatedness (eight items). Example items include "My feelings are taken into consideration in this course" (autonomy), "People in this course tell me I am good at what I do" (competence), and "I really like the people in this course" (relatedness). Internal consistency of the three subscales was satisfactory: autonomy satisfaction (α = 0.74), competence satisfaction (α = 0.73), and relatedness satisfaction (α = 0.85). These variables were measured at the student-level.

Situational Motivation

The Situational Motivation Scale (Guay et al. 2000) was modified to measure students' perceptions of their reasons for participating in the course. The 18-item scale measures the six forms of motivation proposed in SDT (Deci and Ryan 2000): intrinsic motivation, integration, identification, introjection, external motivation, and amotivation. Example items include the following: "Because I really enjoy it" (intrinsic motivation), "Because acquiring all kinds of knowledge is fundamental for me" (integration), "Because it allows me to develop skills that are important to me" (identification), "Because I would feel bad if I didn't" (introjection), "Because I feel I have to" (external regulation), "I don't know. I have the impression I am wasting my time" (amotivation). Internal consistency was very good for all six subscales: intrinsic (α = 0.95), integration (α = 0.86), identification (α = 0.90), introjection (α = 0.85), external motivation (α = 0.83), and amotivation (α = 0.81). These variables were measured at the student-level.

Class-Level Factors

Group work and PBL were measured at the class-level. Faculty members were asked to what extent the class involved group work and PBL. They responded to the questions on a 6-point, Likert-type scale anchored by 1 (*none of the assignments*) and 6 (*most of the assignments*). The information on the course level (i.e., 100-level, 200-level, and 300-level) was obtained from the Office of Registrar. It was coded into two dummy variables with 100-level courses as the reference group. Course field (i.e., STEM = 1 and non-STEM = 0) was coded based on the list identified by the U.S. Department of Homeland Security.

Student-Level Controlled Variables

Several student-level demographic variables were included into the models as covariates to control for their influences in students' perceived knowledge transferability. Gender, URM, and status as a domestic or international student were obtained from the Office of Registrar. Gender was recoded into two dummy variables with male students as the reference group (i.e., Females = 1, Males = 0). URM was recoded into two dummy variables with non-URM as the reference group (i.e., URM = 1, non-URM = 0). Whether students were international or domestic was recoded into two dummy variables (i.e., international students = 1, domestic students = 0), with domestic students as the reference group.

Data Analysis

To test our hypotheses, we conducted a two-level multilevel model using Base SAS 9.4 under Windows7. First, we estimated an unconditional model (see Eq. 1) to calculate the intraclass correlation coefficient (ICC). The ICC informed us of the extent to which

unobserved class characteristics contribute to variations in college students' perceived knowledge transferability. This unconditional model acted as a baseline comparison for subsequent models. Next, we added the student-level controlled variables (see Eq. 2), SDT-related variables (see Eqs. 3 and 4), and class-level factors (see Eq. 5) into the model. The Maximum Likelihood (ML) estimation method was used to assess all models. Model fit was assessed using reductions in − 2 Log Likelihood (− 2LL), Akaike information criterion (AIC), and Bayesian information criterion (BIC). The model with smaller values of AIC and BIC are preferred. The χ^2 Likelihood-ratio tests of differences were conducted when comparing nested models (Tabachnick and Fidell 2007). We calculated the proportional reduction in variance to assess the local effect size.

$$Y_{ij} = \gamma_{00} + u_{0j} + e_{ij} \tag{1}$$

$$Y_{ij} = \gamma_{00} + \gamma_{10}(\text{Female}) + \gamma_{20}(\text{International}) + \gamma_{30}(\text{URM}) + u_{0j} + e_{ij} \tag{2}$$

$$\begin{aligned} Y_{ij} = {} & \gamma_{00} + \gamma_{10}(\text{Female}) + \gamma_{20}(\text{International}) + \gamma_{30}(\text{URM}) + \gamma_{40}(\text{LC}) \\ & + \gamma_{50}(\text{Autonomy}) + +\gamma_{60}(\text{Competence}) + \gamma_{70}(\text{Relatedness}) + u_{0j} + e_{ij} \end{aligned} \tag{3}$$

$$\begin{aligned} Y_{ij} = {} & \gamma_{00} + \gamma_{10}(\text{Female}) + \gamma_{20}(\text{International}) + \gamma_{30}(\text{URM}) + \gamma_{40}(\text{LC}) + \gamma_{50}(\text{Autonomy}) \\ & + \gamma_{60}(\text{Competence}) + \gamma_{70}(\text{Relatedness}) + \gamma_{80}(\text{Intrinsic Motivation}) + \gamma_{90}(\text{Integration}) \\ & + \gamma_{100}(\text{Identification}) + \gamma_{110}(\text{Introjection}) + \gamma_{120}(\text{External Regulation}) \\ & + \gamma_{130}(\text{Amotivation}) + u_{0j} + e_{ij} \end{aligned} \tag{4}$$

$$\begin{aligned} Y_{ij} = {} & \gamma_{00} + \gamma_{01}(200 - \text{level}) + \gamma_{02}(300 - \text{level}) + \gamma_{03}(\text{STEM}) + \gamma_{04}(\text{PBL}) \\ & + \gamma_{05}(\text{Group Work}) + \gamma_{10}(\text{Female}) + \gamma_{20}(\text{International}) + \gamma_{30}(\text{URM}) \\ & + \gamma_{40}(\text{LC}) + \gamma_{50}(\text{Autonomy}) + \gamma_{60}(\text{Competence}) + \gamma_{70}(\text{Relatedness}) \\ & + \gamma_{80}(\text{Intrinsic Motivation}) + \gamma_{90}(\text{Integration}) + \gamma_{100}(\text{Identification}) \\ & + \gamma_{110}(\text{Introjection}) + \gamma_{120}(\text{External Regulation}) + \gamma_{130}(\text{Amotivation}) + u_{0j} + e_{ij} \end{aligned} \tag{5}$$

Here Y_{ij} is the level of perceived knowledge transferability for the ith student in the jth class. γ_{00} is the grand mean score of perceived knowledge transferability. $\gamma_{01} - \gamma_{05}$ refer to the regression coefficients for the class-level factors. $\gamma_{10} - \gamma_{12\,0}$ refer to the regression coefficients for student-level controlled variables and student-level factors. u_{0j} refers to the variance of perceived knowledge transferability between classes after controlling all the predictors. e_{ij} refers to the variance in college students' perceived knowledge tranferability within classes after controlling all the predictors.

Results

Table 1 includes descriptive statistics for all variables of interest. Students in the sample perceived relatively high knowledge transferabilities. Prior to the multilevel modeling analyses, we examined the correlations among the SDT-related predictors as well as the correlation between PBL and group work. Eight correlation coefficients among the SDT-related

Table 1 Unweighted descriptive statistics and zero-order correlations for all variables of interest

Variable	*M*	*SD*	Min	Max	1	2	3	4	5	6	7	8	9	10	11	16	17
Unweighted $n = 3783$ students																	
1. PKTS	5.06	1.41	1	7	1	.55	.57	.68	.46	.68	.65	.79	.07	− .10	− .47		
2. LC	5.38	1.30	1	7		1	.67	.59	.45	.52	.49	.57	.07	− .00	− .33		
3. Autonomy	4.51	0.91	1	7			1	.74	.58	.58	.47	.57	− .05	− .19	− .44		
4. Competence	4.70	0.96	1	7				1	.60	.66	.52	.66	− .11	− .21	− .58		
5. Relatedness	4.76	0.98	1	7					1	.40	.40	.44	− .06	− .03	− .37		
6. Intrinsic	4.22	1.59	1	7						1	.65	.81	.20	− .24	− .37		
7. Integration	4.92	1.28	1	7							1	.78	.22	− .08	− .28		
8. Identification	4.85	1.40	1	7								1	.18	− .15	− .43		
9. Introjection	3.08	1.46	1	7									1	.28	.38		
10. External Motivation	4.72	1.44	1	7										1	.23		
11. Amotivation	2.68	1.38	1	7											1		
Unweighted $n = 301$ classes																	
12. 100-level	0.44	0.50	0	1													
13. 200-level	0.40	0.49	0	1													
14. 300-level	0.16	0.37	0	1													
15. STEM	0.49	0.50	0	1													
16. Group Work	4.09	1.37	1	6												1	0.68
17. PBL	3.02	1.47	1	6													1

Table 2 Multilevel parameter estimates for perceived knowledge transferability

	Model 1: unconditional model			Model 2: controlled variables added			Model 3: LC and BPN added			Model 4: motivation added			Model 5: class-level variables added			Model 6: Model 5 without nonsignificant variables		
	Effect	S.E	*p*	Effect	S.E	*p*	Effect	S.E	*p*	Effect	S.E	*p*	Effect	S.E	*p*	Effect	S.E	*p*
Fixed effects																		
Controlled variables																		
Female				0.12	0.05	.009	0.09	0.03	.007	0.06	0.03	.030	0.04	0.03	.128			
URM				0.30	0.09	.001	0.19	0.06	.002	0.11	0.05	.025	0.12	0.05	.019	0.12	0.05	.014
International				0.17	0.06	.004	0.23	0.04	< .001	< .01	0.04	.807	− 0.01	0.04	.730			
SDT-related variables																		
LC							0.25	0.02	< .001	0.05	0.01	< .001	0.05	0.01	< .001	0.05	0.01	< .001
Autonomy							0.06	0.03	.046	0.05	0.02	.028	0.05	0.02	.043	0.05	0.02	.037
Competence							0.71	0.03	< .001	0.29	0.03	< .001	0.29	0.03	< .001	0.29	0.02	< .001
Relatedness							0.06	0.02	.008	0.01	0.02	.698	0.01	0.02	.619			
Intrinsic										0.05	0.02	.001	0.05	0.02	< .001	0.05	0.02	.001
Integration										0.08	0.02	< .001	0.08	0.02	< .001	0.09	0.02	< .001
Identification										0.47	0.02	< .001	0.47	0.02	< .001	0.46	0.02	< .001
Introjection										− 0.00	0.01	.708	− 0.00	0.01	.768			
External regulation										0.06	0.01	< .001	0.06	0.01	< .001	0.06	0.01	< .001
Amotivation										− 0.09	0.01	< .001	− 0.09	0.01	< .001	− 0.09	0.01	< .001
Class-level variables																		
Group work													− 0.03	0.02	.093			
PBL													0.02	0.02	.251			
STEM													− 0.14	0.04	.001	− 0.13	0.04	.001
200-level													0.13	0.04	.004	0.14	0.04	.001
300-level													0.12	0.05	.022	0.12	0.05	.018
Intercept	5.08	0.04	< .001	5.43	0.11	< .001	0.14	0.12	.239	0.279	0.14	.043	0.34	0.15	.023	0.33	0.13	.015

Table 2 (continued)

	Model 1: unconditional model			Model 2: controlled variables added			Model 3: LC and BPN added			Model 4: motivation added			Model 5: class-level variables added			Model 6: Model 5 without nonsignificant variables		
	Effect	S.E	*p*	Effect	S.E	*p*	Effect	S.E	*p*	Effect	S.E	*p*	Effect	S.E	*p*	Effect	S.E	*p*
Random effects																		
Intercept variance	0.315	0.04	< .001	0.309	0.041	< .001	0.112	0.17	< .001	0.051	0.01	< .001	0.041	0.01	< .001	0.042	0.01	< .001
Residual variance	1.680	0.04	< .001	1.670	0.040	< .001	0.880	0.02	< .001	0.598	0.01	< .001	0.598	0.01	< .001	0.598	0.01	< .001
− 2LL	13,014.0			12,988.8			10,503.5			8984.6			8955.2			8961.1		
AIC	13,020.0			13,000.8			10,523.5			9016.6			8997.2			8991.1		
BIC	13,031.1			13,023.0			10,560.6			9076.0			9075.1			9046.7		
# of parameters	3			6			10			16			21			15		

variables were above .60, which raised our concerns about multicollinearity. To determine whether we have a multicollinearity issue, we computed the coefficients of multiple determination (R^2) and variance inflation factors (VIF). The range of R^2 was between 0.40 and 0.71. The range of VIF was between 1.55 and 3.40. The results above indicated that some multicollinearity was present but not enough to cause problems (O'Brien 2007).

Unconditional Model

The results of the multilevel modeling analyses appear in Table 2. Model 1 was the fully unconditional model, used to partition the total variance in perceived knowledge transferability into within- and between-class components (Tabachnick and Fidell 2012). The average perceived knowledge transferability was 5.08, SE = 0.04, $t = 121.89$, $p < .001$. The intercept variance was 0.315, SE = 0.04, Z = 7.66, $p < .001$, which indicated that college students' perceived knowledge transferability varied significantly between classes. Residual variance was 1.680, SE = 0.04, Z = 41.86, $p < .001$, which indicated that college students' perceived knowledge transferability also varied significantly within classes. Intercept ICC was 0.315/(0.315 + 1.680) = .1579, which indicated that 15.8% of the variance in perceived knowledge transferability could be explained by between-class differences. The ICC values between.05 and .20 are common in cross-sectional multilevel modeling applications in social science fields (Peugh 2010).

Within-Class Model

In Model 2, we examined the influences of student-level controlled variables by adding gender, URM, and status as international or not into the unconditional model. The fixed effects of all three student-level covariates were significant. Female students, URM students, and international students tended to perceive more knowledge transferability than male students, non-URM students, and domestic students, respectively. The proportional reduction in individual-level residual variance was (1.680 − 1.670)/1.680 = 0.0060, suggesting that 0.6% of the between students variance in perceived knowledge transferability could be explained by these student-level characteristics. The conditional ICC was 0.309/(0.309 + 1.670) = 0.1561, which indicated that 15.6% of the variance in perceived knowledge transferability could be explained by between-class differences after controlling the three student-level controlled variables.

We examined the influences of SDT-related variables in two steps. First, we tested a model (Model 3) with perceptions of autonomy-supportive learning climate, autonomy satisfaction, competence satisfaction, and relatedness satisfaction added to Model 2. All of the fixed effects of newly added SDT-related variables were significant. The conditional ICC was 0.112/(0.112 + 0.880) = .1129, which indicated that 11.3% of the variance in perceived knowledge transferability could be explained by between-class differences after controlling the perceptions of autonomy-supportive learning climate and three basic psychological needs. Compared with Model 2, the proportional reduction in individual-level residual variance was (1.670 − 0.880)/1.670 = 0.4731, suggesting that 47.3% of the between-students variance in perceived knowledge transferability could be explained by perceptions of autonomy-supportive learning climate, competence satisfaction, relatedness satisfaction, and self-determined motivation. Therefore, these four SDT-related variables

explained 47.3% of the total 84.4% of the variance in college students' perceived knowledge transferability.

Then, we tested a model (Model 4) with the six situational motivation variables added to Model 3. All fixed effects were significant except for relatedness satisfaction, introjection, and status as an international student. That is, after controlling all other variables, the unique contributions of relatedness satisfaction, introjection, and status as an international student became nonsignificant. The conditional ICC was $0.051/(0.051 + 0.598) = .0786$, which indicated that 7.9% of the variance in perceived knowledge transferability could be explained by between-class differences after controlling all the SDT-related variables and the student-level covariates. Compared with Model 2, the proportional reduction in student-level residual variance was $(1.670 - 0.598)/1.670 = .6419$, suggesting that 64.2% of the between-student variance in perceived knowledge transferability could be explained by all SDT-related variables, which indicates 64.2–47.3% = 16.9% of the total 84.4% between-student variance was explained by the six situational motivation variables.

Between-Class Model

In Model 5, we added group work, PBL, designates a STEM course or not, and the course level into the model to test whether these class-level factors related to college students' perceived knowledge transferability. After controlling all other variables, course level was significantly associated with perceived of knowledge transferability. Specifically, students in the 200- and 300-level courses perceived more knowledge transferability than students in the 100-level courses after controlling all other variables. Students who took STEM courses perceived less knowledge transferability than students who took non-STEM courses. The fixed effects of group work and PBL were not significant. The fixed effect of gender became nonsignificant after controlling the class-level factors. The fixed effects of the SDT-related variables did not change much compared to Model 4. The conditional ICC of Model 5 was $0.041/(0.041 + 0.598) = .0642$, which indicated that 6.4% of the variance in perceived knowledge transferability could be explained by between-class differences after controlling the SDT-related variables, the student-level covariates, and the class-level factors. Compared with Model 4, the ICC reduced by .0144, which suggested that 1.4% of the between-class differences could be explained by the group work, PBL, course-level, and course field. Compared with Model 4, the proportional reduction in intercept variance was $(0.051 - 0.041)/0.051 = .1961$, suggesting that 19.6% of the between-class variance in perceived knowledge transferability could be explained by group work, PBL, course-level, and designation as a STEM course or not. Therefore, these four class-level factors explained 19.6% of the total 7.9% of the between-class variance in college students' perceived knowledge transferability.

Because we had six nonsignificant fixed effects in Model 5, we tested another model (Model 6) without relatedness satisfaction, introjection, gender, status as an international student, PBL, and group work to evaluate whether we could eliminate them from the model. No significant difference appeared in Model 5 and Model 6 as indicated by the small change in -2 log likelihood ($\Delta - 2LL = 5.9$, $\Delta\ df = 6$, $p > 0.05$). Thus, we decided to eliminate these variables from the model. All fixed effects in Model 6 were significant. The strongest predictor of perceived knowledge transferability was identification ($\gamma = 0.46$). The second strongest predictor was competence satisfaction ($\gamma = 0.29$). Interestingly, external regulation was found to be positively associated ($\gamma = 0.06$) with perceived knowledge transferability.

Chi-square difference tests were conducted to compare these six models. Comparing Model 2 with Model 1, the Chi-square change was 25.2, *df* change was 3, $p < .001$, which indicated that Model 2 was significantly better than Model 1. Comparing Model 3 with Model 2, the Chi-square change was 2,485.3, *df* change was 4, $p < .001$, which indicated that Model 3 was a better model. Comparing Model 3 with Model 4, the Chi-square change was 1518.9, *df* change was 6, $p < .001$, which indicated that Model 4 was significantly better than Model 3. Comparing Model 4 with Model 5, the Chi-square change was 29.4, *df* change was 5, $p < .001$, which indicated that Model 5 was significantly better than Model 4. Comparing Model 5 with Model 6, the Chi-square change was 5.9, *df* change was 6, $p = .434 > .05$, which indicated no significant difference in Model 5 and Model 6. Model 6 was more parsimonious as compared to Model 5, so Model 6 was preferred. The nested model tests suggested that Model 6 was the best model among the six models; furthermore, the AIC and BIC of Model 6 were the smallest among the six models, which provided consistent evidence.

Discussion

In the current study we aimed to investigate the factors influencing college students' perceived knowledge transferability from the perspective of SDT. The results of multilevel modeling analyses generally supported our hypotheses. After taking class-level variations and student-level controlled variables into account, college students' perceived knowledge transferability was positively associated with students' perceptions of autonomy-supportive learning climate, autonomy satisfaction, competence satisfaction, intrinsic motivation, integration, identification, and were negatively associated with amotivation, which confirmed our hypothesis. Unexpectedly, perceived knowledge transferability was positively associated with external regulation and was not associated with relatedness satisfaction. In terms of the class-level factors, course field and course level were associated with undergraduates' perceived knowledge transferability.

Students' motivation plays a critical role in college students' outcomes, including perceived knowledge tansferability, as discussed in the literature review. Among the six types of academic motivation, identification, where students identify with the value and importance of learning and accept it as their own (Deci and Ryan 2015), is the most predictive factor ($\gamma = .46$) of college students' perceived knowledge transferability. Several SDT studies have shown the positive effects of identification on college student motivation and academic achievement (Burton et al. 2006) and engagement (Jang 2008; Reeve et al. 2002). Our study extends the SDT literature by relating identification to perceived knowledge transferability. It is not surprising to find that identification plays an essential role in fostering students' perceived knowledge transferability, because students with identification are likely to see the connections between the learning and their personal goals and values, which would increase the intentions and likelihood of applying what they have learned to another class or their future career. The remaining self-determined types of motivation, intrinsic motivation ($\gamma = .05$) and integration ($\gamma = .09$), were associated with perceived knowledge transferability with much smaller effect sizes. This finding is consistent with that of Burton et al. (2006). Although intrinsic motivation is the prototype of the self-determined type of motivation, previous researchers have pointed out that, in educational settings, identification had even stronger positive effects on students' academic engagement, persistence in school, and successful adaption than intrinsic motivation (Burton et al. 2006;

Koestner and Losier 2002). This may be explained by the fact that higher education is not all about fun. To function effectively in college, undergraduates have to involve themselves in activities not inherently interesting to them but valued by teachers, programs, or societies. This argument is supported by our data. The average score of external regulation ($M = 4.72$) was higher than the theoretical midpoint, indicating that many students take a course because they feel they have to. For example, an engineering freshman may not enjoy solving mathematical problems; however, he or she must complete the calculus course to meet the requirement for more advanced engineering courses. In this case, the more the student identifies with the value or importance of taking a calculus course, the more likely he or she is able to apply the knowledge and skills in a new situation. Our findings suggest that the most effective way to promote college students' perceived knowledge transferability is to foster identification. More discussion regarding how to facilitate identification is provided in the implications and future directions section. For the non-self-determined types of motivation, after controlling for other variables, amotivation ($\gamma = -.09$) was negative correlated to perceived knowledge transferability, which supports our hypothesis; however, external regulation ($\gamma = .06$) was positively associated with perceived knowledge transferability. One possible interpretation of the unexpected association concerns the shared variance between external regulation and amotivation that may have resulted in suppression effects in multilevel modeling.

Another salient influential motivational factor is competence satisfaction ($\gamma = .29$). Research has consistently shown that the satisfaction of basic psychological needs for autonomy, competence, and relatedness is related to important outcomes in education (Ryan and Deci 2017). Our findings extend the SDT literature and highlight the dominant role of competence in the context of higher education. In college classrooms, it is possible that students feel confident in applying the knowledge they have learned in class, as long as they have mastered the content, even if they feel controlled through externally enforced pressures or isolated from others.

Relatedness satisfaction was not associated with perceived knowledge transferability after controlling all other variables in the model. Some of the previous studies have also shown that relatedness has either a weak or nonsignificant relation to students' motivation (e.g., Cheon et al. 2012; Hsu et al. 2019; Levesque-Bristol et al. 2010). Is relatedness, therefore, less valuable for promoting college students' perceived knowledge transferability? Probably not. The importance of relatedness in student outcomes has been demonstrated in many studies (e.g., Furrer and Skinner 2003; Trenshaw et al. 2016). In fact, without taking other variables into consideration, relatedness satisfaction was positively correlated with perceived knowledge transferability ($r = .46$, $p < .001$). One possible explanation for the contradictory results might be that relatedness satisfaction affects motivation and other outcomes in an indirect way (Hsu et al. 2019; Levesque-Bristol 2020), through competence satisfaction and identification, so the fixed effect of relatedness satisfaction becomes nonsignificant. The potential mediating effects might also explain the small fixed effect of autonomy satisfaction ($\gamma = .05$). The mediating effect suggests that, in the context of higher education, autonomy and relatedness satisfaction foster the development of an autonomy-supportive learning environment, which in turn promote identification the satisfaction of competence, which then lead to perceived knowledge transferability. Another explanation for the inconsistent evidence regarding the influence of relatedness satisfaction might be that the measure of relatedness satisfaction (BPNS) does not distinguish various sources of relatedness (e.g., student-peer, student–teacher). In a recent study, researchers found that instructor-relatedness was most predictive of student motivation and engagement, but peer-relatedness failed to predict any student outcomes (Fedesco et al. 2019). In

the current study, when students responded to the relatedness items (e.g., "I really like the people in this course"), whether they were reflecting mostly on their teachers, their peers, or a combination of both was unclear.

Implications and Future Directions

This study makes meaningful contributions to SDT and higher education, providing implications for promoting college students' perceived knowledge transferability. Acquiring knowledge might be the primary reason for attending college or university. Nevertheless, using this knowledge to manage everyday and professional life should be emphasized as colleges and universities play a significant role in preparing students for transitioning to the workforce, graduate school, and real life. With the guidance of SDT, we identified significant influential factors that explain a large amount of between-student variance in perceived knowledge transferability. As we noted above, facilitating identification seems to be an effective way to achieve this goal. How can we promote identification among undergraduates? Generally speaking, factors in the social environment that satisfy individuals' needs for autonomy, competence, and relatedness are assumed to facilitate the internalization of nonintrinsically motivated behaviors (Ryan and Deci 2017). Substantial evidence shows what teachers could do to facilitate students' identification, including providing students with choice, acknowledge students' perspectives, providing or encouraging students to generate meaningful rationales if the choice is constrained, and giving timely positive feedback (Deci et al. 1994; Jang 2008; Reeve et al. 2002; Vansteenkiste et al. 2018, 2004). We also suggest instructors put more effort into satisfying students' need for competence. For instance, it is critical to deliberately design learning objectives, activities, and assignments that are within students' zone of proximal development (Sun and Chen 2010), and ensure that those three components are aligned. We by no means propose that autonomy and relatedness are unnecessary. Autonomy and relatedness are indeed important, but achieving them without competence might have minimal positive effect on learning. The potential mediating effects of competence satisfaction on the relationship between autonomy satisfaction and perceived knowledge transferability and the relation between relatedness satisfaction and perceived knowledge transferability helps us understand the mechanism of basic psychological needs and enriches empirical studies on SDT in the educational area.

In addition to pinpointing out the key factors that influence knowledge transfer, by using a multilevel modeling approach we were able to tease out the influence at the class level and identify two significant class-level variables. Specifically, course level and course field were found to be influential: students who took higher-level courses perceived more knowledge transferability than students who took introductory level courses; and students who took non-STEM courses perceived more knowledge transferability than students who took STEM courses. Students taking higher-level courses may have greater content mastery to perceive the possibilities of applying the knowledge (Chi and VanLehn 2012). However, PBL and group work were not associated with perceived knowledge transferability, which supports that incorporating active learning strategies into the classrooms may not necessarily lead to better knowledge transfer (Bonem et al. 2019). The examination of class-level factors is largely overlooked in the literature of knowledge transferability, our findings suggest that future investigation on college students' knowledge transfer could pay more attention to the effects of contextual factors and other potential learning strategies at the class-level.

Based on our findings, we provide several suggestions for future research that adopt the SDT framework to understand college students' learning experiences. First, we propose that the measure of relatedness satisfaction needs to be further explored and perhaps revised to distinguish the various sources of relatedness. Second, the current study was completely cross-sectional. The correlational results cannot demonstrate causal relations among the variables. Other types of research, such as lab experiment and longitudinal research, should be conducted to demonstrate the causal effects of SDT-related variables on college students' perceived knowledge transferability. Third, we call for more studies to examine the influential factors of perceived knowledge transferability from the perspective of SDT. Although the findings of the current study possess the potential for generalizability due to the large diverse sample, our data were collected from a course transformation program at a large, research university that tends to have a greater focus on creating student-centered learning environments. Therefore, it would be beneficial to replicate these results at a variety of different types of institutions. A next step in line with the current research is to investigate the antecedents of college students' competence satisfaction and identification. In the present study, we have demonstrated the importance of competence satisfaction and identification in predicting college students' perceived knowledge transferability. Further analyses of the factors associated with these two variables may provide information for intervention efforts.

Acknowledgements We are grateful to Dr. David Sears, Dr. Signe Kastberg, Qian Li, and Yaheng Lu for their feedback on an earlier version of the manuscript. We thank the reviewers and editors for their thoughtful comments.

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.

Appendix

Perceived Knowledge Transferability Scale

Please consider the following questions as they relate to ⟨Course⟩ and record the extent to which you agree using the choices provided.

(1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = neither agree nor disagree, 5 = somewhat agree, 6 = agree, 7 = strongly agree).

1. I feel confident in my ability to apply the course material in other classes that I have.
2. I feel confident in my ability to apply the course material in my professional life.
3. I feel as if the material covered in this course is relevant to my future career.
4. Given the future career that I have chosen, it is important for me to learn the information covered in this class.
5. I understand how I will use the information learned in this class in my professional life.

6. Information learned in this course will inform my future learning experiences.
7. I believe that it is important for me to learn the information included in this course.
8. The information learned in this course will help me become a more well-rounded individual.

Learning Climate Questionnaire (LCQ) Short Form (Williams and Deci 1996)

The questions below are related to your learning experience in ⟨Course⟩ thus far. The learning experience in different courses can vary and we would like to know more about how you generally feel about the overall learning experience in ⟨Course⟩.

(1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = neither agree nor disagree, 5 = somewhat agree, 6 = agree, 7 = strongly agree).

1. I feel that my instructor provides me choices and options.
2. I feel understood by my instructor.
3. My instructor conveyed confidence in my ability to do well in the course.
4. My instructor encouraged me to ask questions.
5. My instructor listens to how I would like to do things.
6. My instructor tries to understand how I see things before suggesting a new way to do things.

Modified Basic Psychological Needs Scale (BPNS) (Levesque-Bristol et al. 2010)

The following questions concern your feelings about your experience in ⟨Course⟩. Please indicate how true each of the following statement is for you given your specific experiences with <Course> thus far.

(1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = neither agree nor disagree, 5 = somewhat agree, 6 = agree, 7 = strongly agree).

1. Autonomy.

a. I feel like I can make a lot of inputs in deciding how my coursework gets done.
b. I feel pressured in this course.
c. I am free to express my ideas and opinions in this course.
d. When I am in this course, I have to do what I am told.
e. My feelings are taken into consideration in this course.
f. I feel like I can pretty much be myself in this course.
g. There is not much opportunity for me to decide for myself how to go about my coursework.

2. Competence

a. I do not feel very competent in this course.
b. People in this course tell me I am good at what I do.
c. I have been able to learn interesting new skills in this course.
d. Most days I feel a sense of accomplishment from this course.
e. In this course I do not get much of a chance to show how capable I am.
f. I often do not feel very capable in this course.

3. Relatedness

a. I really like the people in this course.
b. I get along with people in this course.
c. I pretty much keep to myself when in this course.
d. I consider the people in this course to be my friends.
e. People in this course care about me.
f. There are not many people in this course that I am close to.
g. The people in this course do not seem to like me much.
h. People in this course are pretty friendly towards me.

Situational Motivation Scale (SIMS) modified version (Guay et al. 2000)

The questions below are related to your feelings of why you are taking ⟨Course⟩. Students have different motivations for taking different courses, and we are interested in your motivations for taking ⟨Course⟩ thus far.

(1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = neither agree nor disagree, 5 = somewhat agree, 6 = agree, 7 = strongly agree).

1. Intrinsic regulation

a. Because I really enjoy it.
b. Because I really like it.
c. Because it's really fun.

2. Integration

a. Because learning all I can about academic work is really essential for me.
b. Because acquiring all kinds of knowledge is fundamental for me.
c. Because experiencing new things is a part of who I am.

3.. Identification

a. Because it allows me to develop skills that are important to me.
b. Because it's a sensible way to get a meaningful experience.
c. Because it's a practical way to acquire new knowledge.

4. Introjection

a. Because I would feel bad if I didn't.
b. Because I would feel guilty if I didn't.
c. Because I would feel awful about myself if I didn't.

5. Extrinsic regulation

a. Because I feel I have to.
b. Because that's what I'm supposed to do.
c. Because that's what I was told to do.

6. Amotivation

a. I don't know. I have the impression I'm wasting my time.
b. I'm not sure anymore. I think that maybe I should quit (drop the class).
c. I don't know. I wonder if I should continue.

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