A CROSS-CLASSIFIED PATH ANALYSIS OF THE
GENERAL SELF-DETERMINATION THEORY MODEL
# ON SITUATIONAL, INDIVIDUAL AND CLASSROOM LEVELS

by

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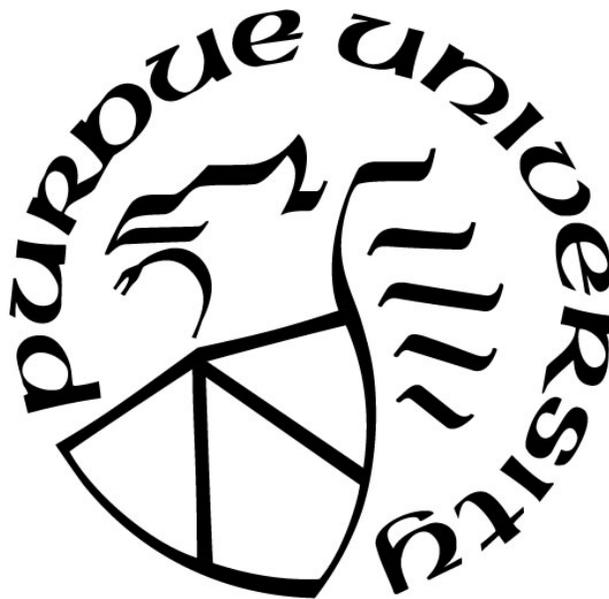
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ABSTRACT

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Title: A Cross-Classified Path Analysis of the General Self-Determination Theory Model on Situational, Individual and Classroom Levels
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According to self-determination theory (SDT), the extent to which students' motivation is self-determined is critical for their academic performance. When self-determined, students learn because of personal interest or identification, out of a sense of volition, as opposed to pressure or indifference. SDT also proposes that self-determined academic motivation is facilitated when the learning environment supports the basic psychological needs for autonomy, relatedness, and competence. This model of social support → needs satisfaction → motivation → learning outcomes is termed the general self-determination theory model (hereafter the General Model), and numerous studies have provided support for it.

However, the current evidence regarding the General Model is limited, in that no study to date has examined it in its full using within-individual methods. Between-individual analytical methods answer the question of whether a person with higher response on variable A is also more likely to report higher levels of B, whereas within-individual analytical methods answer the question of whether the same person is more likely to experience variable B when reporting experiences of A. Despite the popularity of between-individual methods in educational psychology, they may not be able to reveal the within-person relationships between variables, which are critical for understanding inner psychological processes and mechanisms.

Therefore, the current study aims to apply a within-individual analytical approach to the General Model, using a large dataset collected at Purdue over several years. Specifically, in the current dataset, not only may a student provide multiple responses, but also the same classroom contain various students' responses. Therefore, a cross-classified path model is used, such that the General Model is analyzed under the framework of "responses cross-classified under students and classrooms". This model enables me to explain the variance-covariance matrix of the variables using the General Model on three levels: the situational (within-student and within-classroom) level, the student level, and the classroom level.

Results generally supported the predictions of the General Model on the within-individual, within-classroom level. That is, for the same student, in the same classroom, when she or he experiences higher levels of autonomy support, they would also be more likely to have their psychological needs satisfied, and to study for self-determined reasons, which is then associated with higher perceived learning performance. Unexpected findings include the dominant effect of competence, the direct effects of learning climate and competence, and the lack of relationship between grades and other variables. The General Model is also largely replicated on the student- and classroom-levels.

In addition, supplemental analyses showed that (1) although the general trend of motivation and perceived learning climate across one's college life is null, the trend is moderated by major, such that students in business-related majors decrease in self-determined motivation and perceptions of autonomy support, whereas students in social sciences increase in self-determined motivation and perceptions of autonomy support; (2) there is limited and inconsistent support for a buffer effect, such that the higher autonomy and competence needs satisfaction students generally get, the lower their needs satisfaction in a specific classroom depends on the learning climate. Overall, the current research provides a comprehensive and multilevel understanding of the role of self-determination in the classroom.

INTRODUCTION

The current research examines the general self-determination theory (SDT) model by applying multilevel analytical methods to the IMPACT dataset, a secondary dataset that has been collected over the campus for the past three years. This research is an effort in "substantive-methodological synergy" (Marsh & Hau, 2007), aiming at applying advanced statistical methods to achieve a more accurate understanding of complex research problems. Substantially, this research examines the relationships between learning climate, needs satisfaction, motivation and learning outcomes, as proposed by the General Model; methodologically, this research applies a cross-classified multilevel structural equation modeling technique. In the following, an introduction of the General Model (the substantive part) and within-individual multilevel analytical methods (the methodological part) will be provided.

The General Self-Determination Theory Model

The current research questions are based on the general principles of self-determination theory (Deci & Ryan, 2000), and centered on self-determined motivation. SDT proposes that self-determined motivation is critical to the positive functioning of all human beings. Self-determined motivation is defined as the motivation being congruent with the self, or well-integrated by the human organism. When we do things because it is interesting (intrinsic motivation), because it is congruent with our identity (integrated regulation), or because we identify with the value of the behavior (identified regulation), the motivation is congruent with our self, and we are self-determined. In contrast, when people do things because they feel internal pressure and guilt or shame (introjected regulation), because they are coerced by others (external regulation), or they simply have no good reason (amotivation), they are non-self-determined. Self-determined motivation is proposed to contribute to the positive functioning and behavioral and well-being outcomes for human beings (Deci & Ryan, 2000; Ryan & Deci, 2017). For example, research has supported the positive role that self-determined motivation plays in educational achievements (e.g., Fortier, Vallerand, & Guay, 1995; Guay & Vallerand, 1996), engagement (e.g., Bao & Lam, 2008), vitality (e.g., Mouratidis, Vansteenkiste, Sideridis, & Lens, 2011), and subjective well-being (e.g., Vansteenkiste, Zhou, Lens, & Soenens, 2005).

SDT also proposes that the self-determined functioning requires the satisfaction (as opposed to frustration) of certain psychological needs. Decades of empirical research has supported the existence of three basic psychological needs, i.e., autonomy, relatedness, and competence (Deci & Ryan, 2000). Autonomy refers to people's need to self-organize their experiences and self-regulate their behaviors, while frustration of this need involves feeling pressured and internally conflicted. Relatedness refers to the need to establish meaningful relationships with others, to care for others and be cared for, while frustration that is related to this need involves relational exclusion and the feelings of loneliness. Competence refers to the need to feel effective in interacting with the environment, while frustration of this need involves feelings of failure and doubts about one's efficacy.

For example, as shown in research on intrinsic motivation (e.g., Deci & Ryan, 1985), for people to be interested in an activity, it has to be something that we perceive personal agency and volition (autonomy), rather than something we are forced to do; it also requires that the activity makes us feel capable in participation (competence). For another example, for us to whole-heartedly internalize and identify with a social rule that is not interesting to do to begin with (e.g., cleaning the bathroom), this activity needs to be promoted by some socializing agent who cares about the person or the person cares about, or makes the person feel accepted to a greater social matrix (relatedness).

In addition, SDT proposes that the extent to which the three basic needs are satisfied depends on the characteristics of the social context (Deci & Ryan, 2000). For example, autonomy support is the style of social contexts that is most researched in SDT. An autonomy-supportive person (e.g., a teacher) will provide people (e.g., the student) with choices, give rationales that help them connect the activity with their personal relevance, and take their perspectives to make sure that they feel understood and listened to -- all of these behaviors contribute to the satisfaction of the need for autonomy. The other two types of social context that are supposed to mainly satisfy the needs for competence and relatedness are structure and involvement, respectively (these two styles are not covered in the current study).

SDT researchers have also argued that social contexts that support one need also tend to support other needs (e.g., Vansteenkiste, Niemiec, & Soenens, 2010). For example, a parent who is sensitive to children's feelings and needs not only supports children's autonomy, but may also foster a closer relationship with the child, and be able to provide information and challenge

according to accurate perception of the child's conditions. Therefore, although autonomy support is proposed to mainly contribute to the need for autonomy, it is also expected to predict higher levels of relatedness and competence satisfaction.

To summarize, according to SDT, we would expect positive relationships between the social context, needs satisfaction, motivation, and behavioral and experiential outcomes. This set of propositions are termed the General Model in the current research, and is illustrated in Figure 1 (adapted from Yu, Chen, Levesque-Bristol, & Vansteenkiste, 2018). Specifically, in the current research we focus on examining these propositions in an educational context. This model has been supported using between-individual method by recent research (e.g., Garn, Morin, & Lonsdale, 2018).

The substantial part of the research questions to be answered in the current research is: Does an educational context (e.g., classroom environment) that provides autonomy support make students feel that they are autonomous and volitional (autonomy need satisfaction), that they have good connections with people (relatedness need satisfaction), and that they are becoming more capable at the subject (competence need satisfaction)? Do these need satisfaction experiences subsequently make the students more likely to study out of interest and identification, rather than internal and external pressures (i.e., self-determined academic motivation)? Can we observe higher grades and subjective learning outcomes following more self-determined motivation? Does this whole set of prediction sequences hold together?

Need-Supportive Social Contexts   **Need Satisfaction**   **Self-Functioning**   **Outcomes**
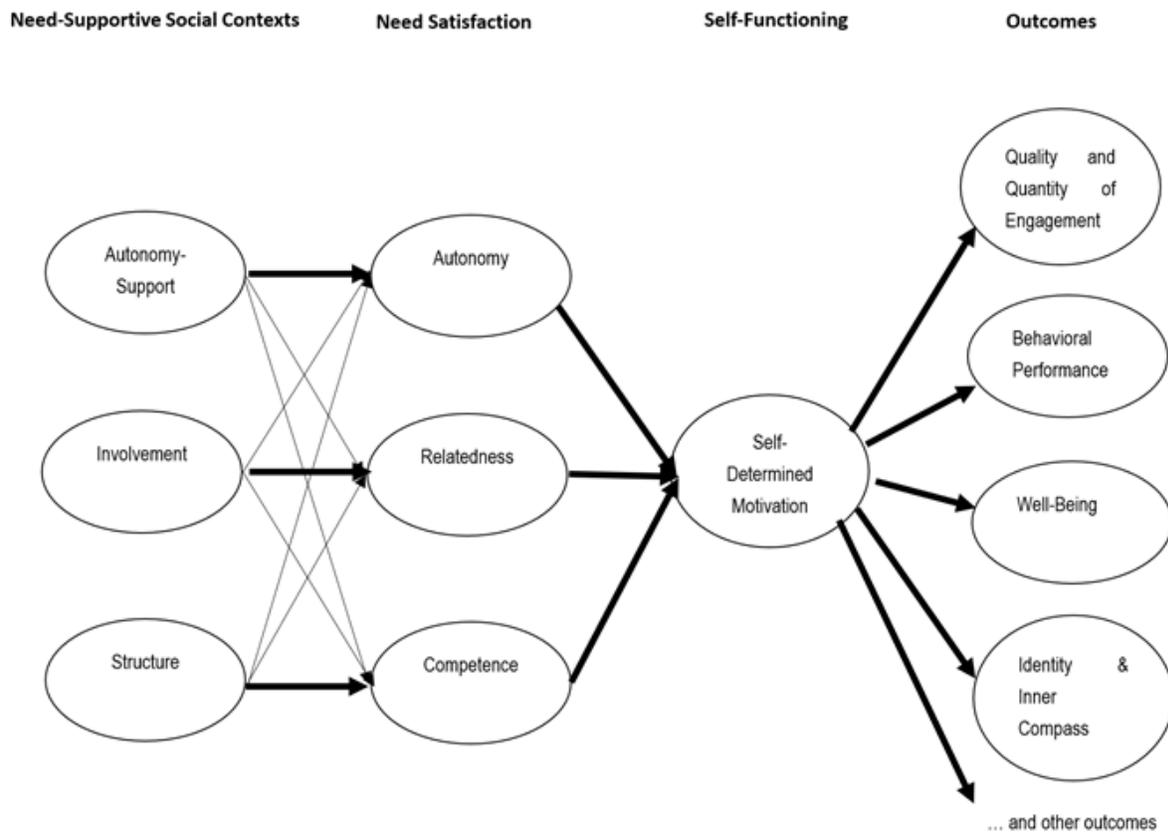
Figure 1: The General SDT Model
(Reproduced from Yu, Chen, Levesque-Bristol, & Vansteenkiste, 2018).

The Alternative Self-Determination Model in Education

Recent research that tests this model in educational settings (e.g., Levesque-Bristol et al., under review; Ntoumanis, 2001) found that the need for competence has a dominant effect on motivation in the classroom. Therefore, Levesque-Bristol et al. (under review) proposed that the effects of the needs for autonomy and relatedness on motivation may be mediated by the need for competence. That is, at least in college setting, it is possible that students feeling competent at the course is the most direct predictor of their self-determined academic motivation, and the experiences of autonomy and relatedness are related to self-determined motivation because they contribute to competence. This model presents a slightly different possibility, and it will be explored as an alternative to the primary model previously introduced.

Beyond these substantive questions, the current research also aims to upgrade the methods that is used to examine these research questions. Below we turn to this methodological focus in detail.

Within-Individual Research Design

The General Model is posited to function at both the general between-individual level and the situation-specific within-individual level (Ryan & Deci, 2017). That is, there are variations of the variables shown in Figure 1 both from person to person, and from situation to situation (for the same person); whether it is at the between-individual or situation-specific level, SDT proposes that higher needs support lead to needs satisfaction, which then lead to better quality of motivation and performance.

However, the majority of research evidence so far has examined the between-individual relationship between these constructs. Between-individual relationships between variables could be very different from within-individual relationships for the same variables (examples can be found in Borsboom, Mellenbergh, & Van Heerden, 2003; Fisher, Medaglia, & Jeronimus, 2018; Hamaker, 2012; Huta, 2014; Marsh et al., 2008; Molenaar, 2004; Murayama et al., 2017; Stapleton, 2013; among others). To illustrate, imagine that Figure 2 shows the bivariate relationship between self-determined motivation (on the horizontal axis) and grades (on the vertical axis), and the dots within the same circle represent multiple responses coming from the same individual. In this hypothetical scenario, although the overall pattern is consistent with cross-

sectional research findings, i.e., students who are more self-determined have higher grades, this tells us little if the same student would have higher grades in courses where he or she is more self-determined. Therefore, within-person designs on the General Model are needed because they provide stronger evidence to inform us about the behavioral and psychological mechanisms that happens within those individuals.

Over the last 10 years or so, SDT researchers have realized the limitations of between-individual designs, and within-individual studies using repeatedly measured surveys and analyzed using multilevel modeling have been started. For example, one of the earliest within-individual research that applies SDT in educational settings is by Tsai, Kunter, Ludtke, Trautwein, and Ryan (2008). By focusing on the within-person, lesson-to-lesson variations in classroom experiences, they were able to show that in classes where 7th grade students perceived higher autonomy support (vs. controlling) teaching, they are also likely to experience interest in learning. Another one of the earlier studies in this field was by Mouratidis, Vansteenksite, Sideridis, and Lens (2011), who manipulated need-supportive teaching and self-determined motivation from class to class, and observed Greek pupils' vitality and interest-enjoyment. By focusing on repeated measures within the same pupils, they were able to show that in classes that are higher on need-supportive teaching and self-determined motivation, the same pupils tend to have higher vitality and interest-enjoyment.

Subsequent research has investigated in school settings the within-individual effects of teacher needs support on self-determined motivation (Stroet, Opdenakker, & Minnaert, 2015), instruction style on perceived autonomy support and positive emotion (Bieg et al., 2017), basic psychological needs satisfaction on emotional engagement (e.g., interest and enjoyment; Park, Holloway, Arendtsz, Bempechat, & Li, 2012), and self-determined motivation on affective and behavioral outcomes (e.g., vitality, interest/enjoyment, effort, and procrastination; Mouratidis & Lens, 2015). These research has been able to control for individual differences and demonstrated at the intra-individual level the validity of paths included in the General Model.

Furthermore, in the last two or three years, another more advanced trend in data analysis that has been applied in within-individual research in SDT is multivariate multilevel modeling, or also referred to as multilevel structural equation modeling (ML-SEM). This approach combines the advantage of both SEM and multilevel modeling, and is able to simultaneously control for measurement error due to sampling of items and the non-independent errors due to nested data

(Marsh et al., 2009; Marsh et al., 2012). The methodological advantage of using ML-SEM in SDT research is that it can holistically examine multiple within-individual relationships in the General Model at the same time. In recent years, this approach has been applied in various subfields of SDT research, including general psychological needs research (Neubauer & Voss, 2016), organizational behavior (e.g., Conway, Clinton, Sturges, & Budjanovcanin, 2015), and sport and exercise (Madigan, Stoeber, & Passfield, 2016).

Among these research that applied the advanced within-person multilevel SEM, two studies have applied ML-SEM to SDT research in educational psychology specifically. First, Malmberg, Pakarinen, Vasalampi, & Nurmi (2015) repeatedly measured primary school students' learning experiences over one week (each student has an average of 11 learning episodes measured), and they found a within-individual association between controlled motivation and autonomous motivation. In another study, Bartholomew et al. (2017) measured middle school students each trimester over one school year, and found that at the within-individual level, controlling teaching predicts needs frustration, which then predicts self-determined motivation. The within-individual indirect effect of controlling teaching on motivation is also significant. Therefore, with a ML-SEM approach, Bartholomew et al. (2017) were able to support the within-individual relationships between instructional context, needs frustration, and motivation simultaneously.

In sum, over the last 10 years or so, SDT research in educational settings that applies a longitudinal within-person design has burgeoned. However, the current literature has several limitations. First, most research has incorporated only part of the General Model shown in Figure 1, and many research questions that are involved in the General Model have not been examined. As a specific example, few studies have answered questions related to students' within-individual changes in grade performance. Also, no study has incorporated all four stages of the model shown in Figure 1. Thus, in my dissertation, I propose to apply within-individual analyses (specifically, ML-SEM) to the course-to-course variation in students' self-determined motivation and related variables, to answer unexamined research questions derived from the General Model.
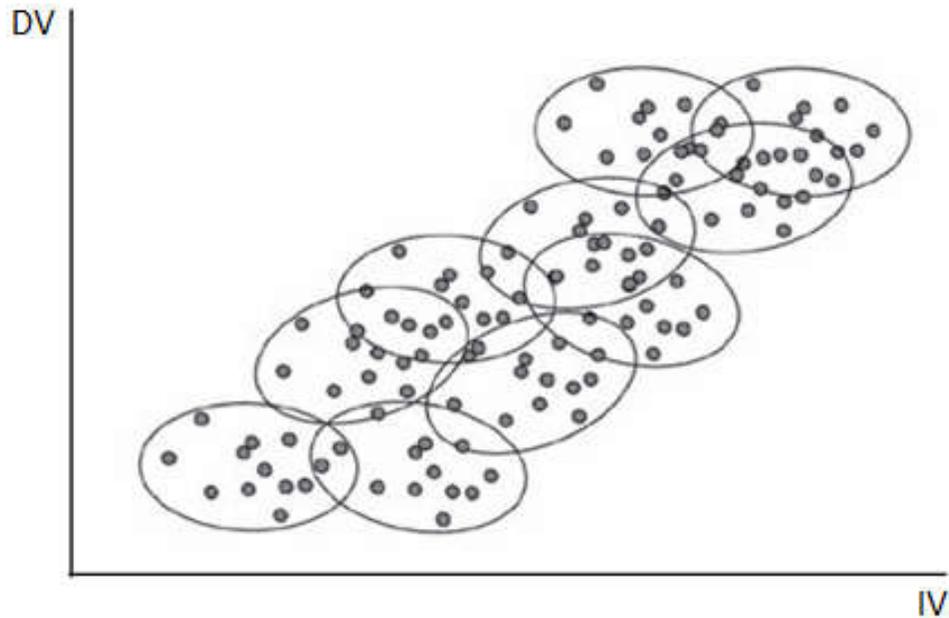
Figure 2: Relationships Within and Between Nesting Units
Figure is a modification based on Stapleton (2013, p. 527).

Additional Considerations and Supplemental Questions

Research in College Students

Because of practical considerations (the dataset we have is college students), I will use college students as the sample in the current research. Nevertheless, from a conceptual perspective, college education is also especially pertinent for examining the research questions related to the General Model. First, unlike secondary education, students no longer study a uniform curricula, and there may be more variations in how they would engage in learning activities, so the role of motivation may be even stronger for them. Second, college is an important stage in the lives of contemporary youths when they make important career commitments (e.g., Hargrove, Creagh, & Burgess, 2002) and identity formation progress (Arnett, 2000). The college learning experience has profound implications for the remainder of their lives (e.g., Janos, 1987; Thomas & Zhang, 2005). Given that SDT claims universality for its propositions, and that college is a critical life stage, it is important to answer the research questions with college samples.

Specifically, a few studies have provided evidence for this model in college students. Some research has shown the positive effects of basic needs satisfaction (Kanat-Maymon, Benjamin,

Stavsky, Shoshani, & Roth, 2015) and self-determined motivation (Gillet, Morin & Reeve, 2017; Gillet et al., 2017; Senecal, Julien, & Guay, 2003) on academic outcomes. A few other studies have applied a more holistic perspective and included multiple paths in this model. For example, several studies have shown that needs support in the educational contexts predict autonomous motivation, which subsequently predict academic outcomes (e.g., William & Deci, 1996; Levesque, Zuehlke, Stanek, & Ryan, 2004; Vansteenkiste, Simons, Lens, Sheldon, & Deci, 2004; Vansteenkiste, Sierens, Soenens, Luyckx, & Lens, 2009). In addition, Jang, Reeve, and Halusic (2016) found that perceived autonomy support in the classroom predicts satisfaction of the need for autonomy, which then predict engagement and learning outcomes. In short, parts of this model have gained empirical support, although there still exist substantial questions about this model that has not been tested with college students. For example, no study has incorporated all four elements (i.e., contextual support, needs satisfaction, self-determined motivation and behavioral outcomes) and demonstrated the validity of this model in its totality with college students.

Therefore, by focusing on these overlooked issues, the current study will make a contribution to our understanding of SDT principles in college learning in particular.

In addition to examining the research questions related to the General Model with a college sample, the current research also has two supplemental research questions of exploratory nature, which are introduced below.

Change of Self-Determined Motivation over Time and the Moderation of Major

First, the question of how self-determined motivation change over time is one that has always intrigued SDT researchers. Prior research has examined this question mostly in primary and secondary school students, which generally led to the conclusion of deterioration in both the quality (i.e., decrease in the degree of self-determination; e.g., Otis, Grouzet, & Pelletier, 2005; Ntoumanis, Barkoukis, & Thogersen-Ntoumani, 2009; Bartholomew et al., 2017) and quantity (i.e., intensity of motivation, regardless of whether the motivation is self-determined or non-self-determined; e.g., Corpus, McLintic-Gilbert, & Hayenga, 2009; Hayenga & Corpus, 2010) of motivation, although there are a few studies that found the opposite (e.g., Kyndt, Coertjens, Daal, Donche, Gijbels, & Van Petegem, 2015). As mentioned previously, because college students may have more autonomy in their learning process, their trajectories of change in self-determined motivation may be different from primary and secondary school students. Therefore, it is

meaningful contribution to the literature to examine how *college students'* motivation change over time (across semesters) in the current dissertation. In the current research I will be able to do so while controlling for other predictive variables in the General Model. Also, one possible explanation of potential change in motivation is the change in perceived learning climates; in the current study, the temporal trend in perceived learning climates can also be examined.

In addition, previous research has pointed out that there is a difference in the level of self-determined motivation between college majors. For example, Yu and Levesque-Bristol (2018) found that students in social sciences are more self-determined than those who are in business-related majors. Some research (e.g., Sheldon & Krieger, 2004, 2007) also suggested that the deterioration of self-determined motivation may be more pronounced in certain types of majors. Therefore, in the current dissertation, the interaction effect between time and the type of major on motivation can also be examined, to explore in general what types of majors are more vulnerable to the potential deterioration in motivation. As an additional exploration, the change in basic needs may also be examined.

In short, my first set of supplemental questions are: How does self-determined motivation change over time? Is it different for students in different majors?

Moderation of Individual Differences

As mentioned previously, the constructs proposed in the General Model are said to operate on different levels of psychological experience. For example, at the situational level, a student's experiences of need satisfaction and motivation may vary from course to course, but at the individual level, students also differ in terms of how their need for autonomy are generally satisfied, and how self-determined they generally are towards their studies. Previous research has shown that the SDT propositions are valid at both situational and individual-difference levels (e.g., Mouratidis et al., 2011). Importantly, researchers have been interested in a question of cross-level interaction: Do students who are generally more self-determined differ from those who are less self-determined, in terms of how they are affected by the needs support and satisfaction? On the one hand, it is possible that there is a "synergistic" or "matching" effect, where individuals whose needs are more satisfied and who are more self-determined benefited from situational needs support more; one the other hand, it is also plausible that there is a "needing" or "buffering" effect, where less self-determined individuals or individuals whose needs satisfaction are lower benefited

more from situational needs support or satisfaction (because they are in more desperate craving for needs satisfaction), and vice versa, individuals who are high on trait-like self-determination are buffered against the effect of low situational needs support or satisfaction (for a graphical representation, see Mouratidis et al., 2011).

Previous research has examined this issue, but mixed findings have emerged. For example, some research (e.g., Moller, Deci, & Elliot, 2010; Mouratidis et al., 2011; Reis, Sheldon, Gable, Roscoe, & Ryan, 2000) supported the synergistic effect, while other research (e.g., Black & Deci, 2000; Hagger & Chatzisarantis, 2011; Levesque-Bristol et al., under review; Tsai et al., 2008) supported the opposite direction of interaction effect. Our examination will contribute to the pool of empirical evidence for this ongoing controversial issue. In addition, previous studies have mostly examined this issue by measuring individual-level variable with a single individual-level measure. The current study extends previous findings by representing the overall level of individual needs satisfaction using a latent individual-level needs satisfaction variable formed from aggregating the needs satisfaction experiences in separate courses.

To sum up, the research questions are: Do experiences of autonomy support in the learning environment predict needs satisfaction, which then predict self-determined motivation, which then predict learning outcomes, in college students, at the within-individual level? Can we identify change trajectories in college students' self-determined motivation, and how it may differ between majors? Is there a moderation effect of general individual-level self-determination on how students are affected by needs support and needs satisfaction experiences?

The Current Research

The purpose of the dissertation is to identify the within-person relationships between the SDT variables in a college sample collected in a large comprehensive public university in Midwest US. I will conduct a comprehensive examination of the General Model (as shown in Figure 1) with secondary data. Specifically, because of the nested nature of this data (responses nested within students), I will examine how an autonomy-supportive learning climate contributes to the satisfaction of the three basic needs, which then contribute to self-determined motivation, which then predict grades and other learning outcomes, using multilevel SEM.

Notably, in the current dataset, the responses are not only nested within students, but also within classrooms. That is, just like one student may provide multiple responses, one classroom

also contains multiple responses. Because one student can take survey in multiple classrooms, and one classroom can be taken by multiple students, students and classrooms are cross-classified (Raudenbush & Bryk, 2002; Ye & Daniel, 2017). Therefore, the nesting of responses under courses also needs to be addressed using multilevel modeling. It has been a widely applied practice to use multilevel modeling to account for classroom and other school nesting structures (e.g., Lüdtke, Robtzsch, Trautwein, & Kunter, 2009), including in SDT research (just to list a few examples: Aelterman et al., 2012; Jang, Reeve, & Deci, 2010; Nie & Lau, 2009; Taylor & Ntoumanis, 2007). However, no study has simultaneously controlled for course variation and student variation to examine the within-individual experiences of autonomy-support, needs satisfaction, self-determination, and academic achievement. The current research aims to provide an accurate evaluation of the General Model, by controlling for student-level and classroom-level variations.

Based on the full model shown in Figure 1, a model to be tested is shown in Figure 3. In this figure, the thickened arrows are the core relationships we propose based on the General Model. The thinner arrows are of secondary theoretical interest. The dashed arrows are of exploratory nature. As can be seen, the relationships asked by the core research questions are shown as the prediction of autonomy support → needs satisfaction → self-determined motivation → learning outcomes, at the within-individual, within-classroom level (level-1). This means that when the same student in the same classroom experiences more autonomy support, his or her psychological needs are expected to be more satisfied, and he or she is expected to be more self-determined in studying, which subsequently predicts higher grades and perceived learning gains in that class. In other words, the research questions are:

[**Main Research Questions**] Do classroom climates predict college students' need satisfaction, which then predict student motivation, which then predict learning outcomes, after controlling for student- and classroom-level variations?

At the between-individual and between-classroom levels (the two level-2s), the predictive paths between autonomy support, needs satisfaction, motivation and performance are also estimated, but are of lesser theoretical interest. Latent variables at level-1 and the two level-2s jointly explain the variances of the observed variables.

Above and beyond these core research questions, the multilevel SEM approach also allows us to investigate two other supplemental research questions of more exploratory nature. The first set of supplemental questions are:

[Supplemental Research Question 1] How does self-determined motivation change over time? Is it different for students in different majors?

The time variable (time-varying, with values of 1 to 7, representing the seven semesters covered in the dataset) is represented by a rectangle in the level-1 part of the model (Figure 3). These research questions are represented as the dashed arrows from time to self-determined motivation on the within-individual level, as well as the arrow from major on between-individual level to the arrow from time to motivation. The time effect on psychological needs is not shown in the figure.

It should be noted that in the current research, the effect of time (growth or change in motivation) is intertwined with several other variables: the effect of taking many IMPACT courses (including familiarization and intervention effect), and the history (cohort) effect. These other effects can be partially controlled for by including covariates that represent participants' cohort, and the number of IMPACT surveys they have taken at a particular time. More on this issue will be discussed in the Limitation and Threat to Internal Validity section at the end of Methods.

A second relatively exploratory research question is:

[Supplemental Research Question 2] Does the overall individual level of student needs satisfaction moderate the effect of experiences of classroom autonomy support on need satisfaction in a specific classroom?

This second set of research questions is represented as dashed arrows from autonomy need satisfaction and self-determined motivation on the between-individual level, to the arrows from perceived autonomy support to autonomy need satisfaction, as well as from needs satisfaction to self-determined motivation, on level-1.
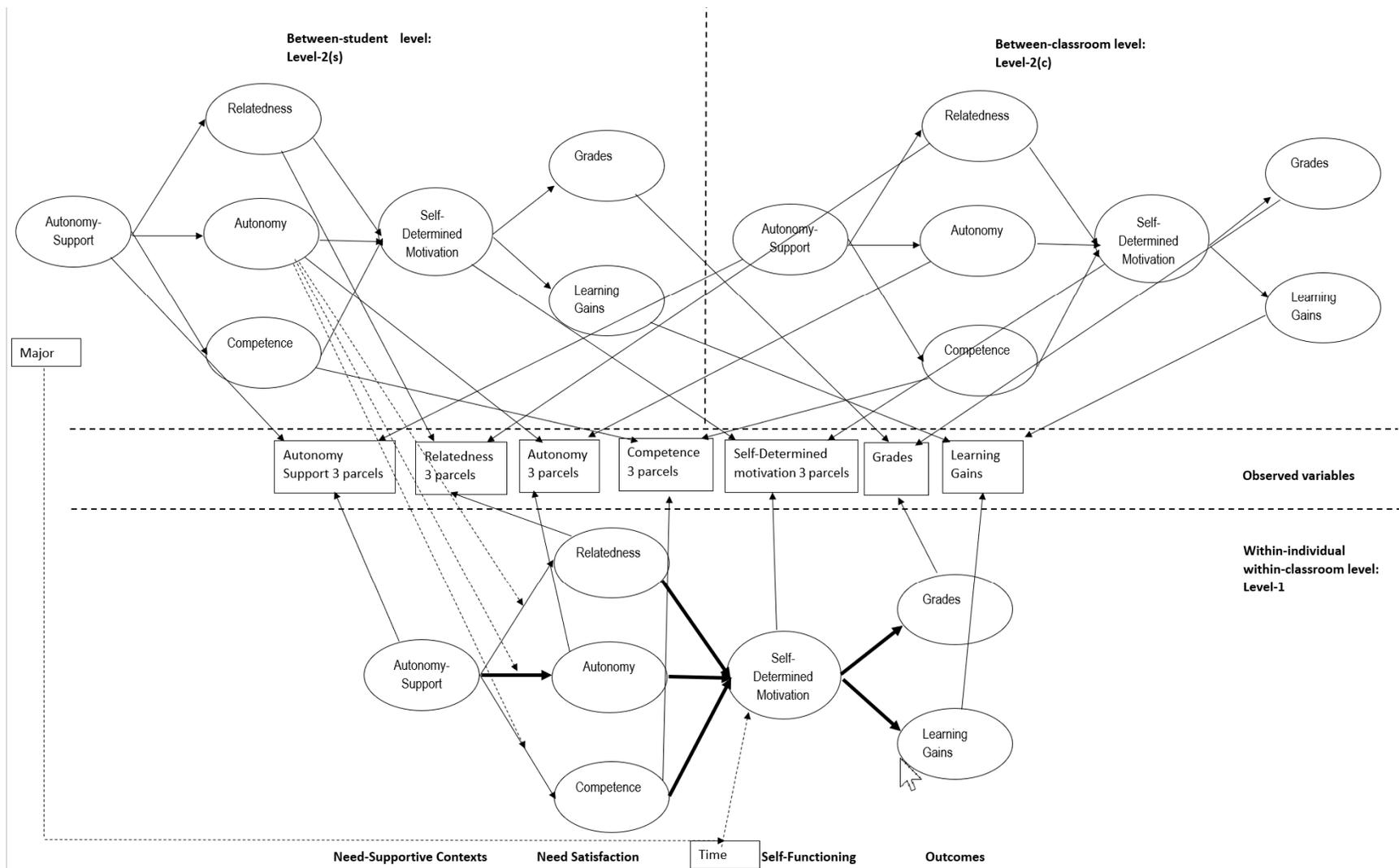
Figure 3: Structural Model Tested in the Dissertation (Simplified Diagram)
Rectangles represent observed indicator variables, while ellipses represent latent constructs. Thickened arrows represent core hypotheses; dashed arrows represent explorative hypotheses. Residual terms and correlations are omitted, and parcels under the same latent construct are combined for clear representation.

Significance of the Study

The significance of this dissertation mainly lies in comprehensively and holistically examining the SDT General Model using a within-person design, with relatively recently advanced methodology and a decent-sized college sample. It is able to control for both student-level and classroom-level variations, to provide an accurate estimate of the within-individual and within-classroom effects proposed in the full General Model. The comprehensiveness of the theoretical model and the rigor of methodology is unprecedented in the literature. Overall, this research will provide strong empirical examination of SDT by combining theoretical insight, advanced methods and relatively big data.

Practically, this research will provide guidance for higher education. As mentioned previously, prior within-individual research in SDT in educational settings mostly focused on secondary education; the current research will further consolidate the importance of self-determined motivation, needs satisfaction and need-supportive learning climate, for college learning, and consequently produce practical impact for instructors and administrators in higher education. For example, the current results will provide a guidance to instructors in their course redesign attempts, by emphasizing the importance of considering students needs satisfaction and motivation; as another example, administrators who are concerned with their students' academic adjustments can try to foster a culture that support students' needs.

LITERATURE REVIEW

This part will aim to provide a conceptual background that contextualizes the research questions introduced in the first section (Introduction). I will provide a summary of previous literature that give rise to the research questions.

Theories of Motivation in Education

In this section, I will review the well-known theories of motivation. This part will explain why I would focus on self-determination theory (SDT) as my central theoretical framework. I start with historically classic theories, including psychoanalysis, behaviorism, and humanism; then I discuss relatively more contemporary theories. After reviewing the following theories, I will draw conclusion that SDT offers a unique perspective to study motivation, because it focuses on the growth-oriented motivation using a comprehensive and empirically based framework, which provides powerful explanations beyond the other theories.

Historical Theories

The word motivation comes from the Latin word *movere*, which means movement. Hence, the study of motivation concerns studying why people are moved to engage in their behaviors. This is an important topic in understanding human psychology, and hence a central concern in arguably all the classic theories in psychology. From the earliest era of psychology, Freud (e.g., 1927) has formulated his psychoanalytical theory, which posits an understanding of human behavior and personality as being fundamentally driven by the sexual instinct (libido), and later, the destructive instinct. All human behavior, according to Freud, can be understood as directly or indirectly being motivated by these instincts. Some behavior (such as learning in the classroom) may seem as nothing to do with the instincts, but according to the psychoanalytic theory, that is because the instincts have been transformed into something more socially or morally acceptable. Because the instincts are usually in strong conflict with reality or with social sanctions, people develop a mental function that moderates these instincts -- this part of the self-structure is termed the *ego*. Further into development, people also internalize the social sanctions, and form the part of self that supervises one's behavior to make sure that it conforms to social rules -- this part is

termed *superego*. Hence, the psychoanalytic theory sees human motivation processes as a struggle involving biological urges and social sanctions, which are represented by the three components of the self. Another historical theory that is similar to the Freudian theory in the sense of emphasizing the fundamental role of physiological instincts is *drive theory*, which posits that behaviors are motivated by the pursuit of homeostasis, or the optimal states of bodily needs (e.g., food and sex).

Freud's theory has been developed by heavily relying on introspection. In a reaction against this limitation, and an attempt to make psychology more "scientific" and objective, behaviorism started to develop in late 19th century, with Ivan Pavlov's (1927) classic conditioning experiments, and rose to the center of stage within psychology around mid-20th century, with B. F. Skinner's (1972) operant conditioning experiments. The core feature of behaviorism is that it proposes that only objectively observable behavioral phenomena can be studied by psychology (methodology behaviorism), and those subjective experience that cannot be observed should be dismissed (e.g., Skinner, 1972). Therefore, motivation as seen in behaviorism has nothing to do with an individual agentically going after an activity. Rather, behaviorism sees motivation as manifest in the frequency or the form of behavior, as a function of environmental events and stimuli. Therefore, to say a student is more motivated in learning is to say she or he are more likely to engage in tasks, persist at them, and expend effort. Behaviorism sees behavior mainly as being shaped by environmental stimuli (e.g., reinforcement). In the second half of 20th century, social cognitive theory represents a development in behaviorism, in the sense that behaviors can be motivated or reinforced via vicarious processes. Therefore, a student could observe her or his peers and be motivated to engage in certain behavior accordingly.

The Freudian theory was based in clinical studies of neuroses and psychopathology, and sees human behaviors as being determined by instinctive drives; the behaviorist theory was based in studies of infrahuman subjects, and sees human behaviors as being mechanistically determined by environmental stimuli. Neither these theories address our everyday experiences of being a free person who has an internal need to grow and develop, as opposed to merely being determined by objective factors. Therefore, humanism started to develop as *the third force* in psychology, in reaction to the limitations of psychoanalysis and behaviorism. For example, Abraham Maslow (1954) and Carl Rogers were two of the most prominent humanistic theorists. The most well-known in Maslow's theory is the hierarchy of needs, which proposes that, although people have all kinds of physiological and psychological needs, the most important need for a person's

development is self-actualization, or the realization of one's potential and full capacities. In Rogers' (1963) theory, human beings are driven by an actualizing tendency toward personal growth, or "being something", developing into a well-integrated, fulfilled, and well-functioning organism. Rogers believes that human beings are naturally curious about their world and eager to learn; the role of education hence is to facilitate the motivation that is inherent to children. As can be seen, the common perspective in humanism is seeing students as holistic persons who can make choices to fulfill their potentialities; educators should provide satisfaction for their needs and facilitate this intrinsic tendency toward learning and development.

Humanism represents a theoretical evolution that transcends previous theories and addressed their limitations, such as the lack of the discussion of freedom, volition, and other intuitive human experiences (e.g., Baumeister, 2008). However, it was mostly popular among clinicians, who most often focused on case studies and downplayed the role of testing their theories using empirical methods (Sheldon & Kasser, 2001). In the second half of 20th century, with the rise of cognitive revolution, psychologists started to focus on studying mental structures and representations with an empirical spirit. In the field of motivation, a few of these theories that aim to study motivation using cognitive constructs (or empirically measurable psychological constructs in general) are expectancy-value theory, attribution theory and achievement goal theory. Below I will review these theories, along with how they relate to SDT.

Contemporary Motivation Theories

Expectancy-value theory

Expectancy-value theory explains motivation toward an activity using (1) expectancies, or individuals' beliefs and judgments about their capabilities to perform tasks successfully, and (2) values, or individuals' beliefs about the reasons they might engage in tasks. Colloquially speaking, individuals will ask themselves "Can I do this task?" and "Is this task of use to me?" before being motivated to engage in the activity. The strength of motivation has been calculated as a product of the probability of success and the incentive value.

Expectancy-value theory provides valuable insights for the determinants of motivation, and much of its components are consistent with SDT. For example, the idea of expectancy is closely related to perceptions of competence, or students' self-evaluative judgments about their abilities

to accomplish certain tasks. In SDT, competence is also considered as a major determinant of motivation. Similarly, the values in expectancy-value theory have been categorized into various types, such as interest-enjoyment, attainment value, utility value, and cost. These considerations of the heterogeneity of values is consistent with the different types of motivation in SDT.

However, there are several limitations of expectancy-value theory. First, as the equation "motivation = expectancy*value" suggests, although expectancy-value theory acknowledges different types of values, these types are all boiled down to one number in the equation that predicts motivation. This is contradictory to the humanistic spirit, because a student studying because she or he really identifies with the importance of education (attainment value, in expectancy-value theory's categorization) may be qualitatively more in line with their internal growth and self-fulfillment tendencies, than the value of "because everyone else is studying and I want to be accepted by others", which involves alienation rather than agency. Henceforth, even if the perceived value in the equation has the same numeric value, they will lead to quite different motivational outcomes. Another limitation is that expectancy-value theory tends to focus on deliberate calculations before deciding to be engaged in an activity. It seems less apt to explain spontaneous behaviors, such as when a kid first time seeing a guitar they start playing with the strings. In such spontaneous situations, it is unknown how much pleasure one can derive, and people usually do not calculate such values. The "value" of such intrinsically motivated behaviors often just unveils while one engages in them, rather than being separately calculable.

Attribution Theory

Attribution theory studies what people are motivated or not motivated to do, as a result of how they attribute their previous experiences with the particular activity. As an example, a student may have done well in the last chemistry test, and they may attribute this fact to their putting more effort into preparing for the exam; hence, they will put more effort next time into the exam again. Besides effort, other common attributions include ability, luck, task difficulty, the teacher, personal physical or psychological conditions, etc. According to the most well-known version of attribution theory, which is Weiner's (1986) model, these attributions can be organized along three dimensions: stability (stable vs. instable over time), locus (external vs. internal to the person), and control (controllable vs. uncontrollable). The attribution along these dimensions will have important consequences for individuals' expectancies for success (Graham & Williams, 2009). If

success is attributed to an internal and stable cause (e.g., "I did well on the test because I'm smart."), the student will expect to succeed in the future; however, if success is attributed to an unstable cause (e.g., "I did well because I made lucky guesses."), then the student will not expect to do as well in the future. For failures, the more adaptive attributions to make are to unstable and controllable causes.

Attribution theory focuses on one very important facet of human motivation, which is to understand one's behavioral contingencies and achieve predictability of one's behavioral outcomes. If one perceives external locus of control, they will perceive the behavior and outcome to be independent (i.e., believing that acting will not yield a desired outcome) or a feeling of incompetence. This will result in one being not motivated to engage in the activity. In fact, this idea has been incorporated in SDT in the form of perceived locus of causality (note the different terminology here from Weiner's classic attribution theory, which used locus of control) and competence need. Actions and/or their outcomes could be perceived as either intentional and thus personally caused or nonintentional and thus impersonally caused. believing an outcome to be impersonally caused means that one thinks it was not within the person's control or competence to bring it about (or to prevent it). In such cases, the behavior will not be motivated. Therefore, SDT is consistent with attribution theory on this point.

However, the classic attribution theory (Weiner's model) also falls short in explaining a dimension of attribution that has important implications for individual growth and fulfillment. For example, even if an activity is perceived as internal to the person, instable, and controllable (or in Heider's terms, personally caused), there is still potentially a great amount of variation in the perceived freedom and volition in that action, which explains a lot of the behavioral outcomes. I "had to" conform to the classroom rules, or my instructor "makes us" complete the boring drills and homework -- the attribution theory does not explain why these situations, which are attributed to controllable personal actions, lead to much worse outcomes than other forms of (equally internal and controllable) perceptions, for example, "the drills and homework are useful for consolidating what we have learned in class". In SDT, this limitation is resolved by considering the internal vs. external perceived locus of causality (I-PLOC and E-PLOC).

The Achievement Goal Approach

The achievement goal approach is a group of theories that share a focus on studying goal orientations or the purposes for engaging in tasks (Vansteenkiste, Lens, Elliot, Soenens, & Mouratidis, 2014) as a way to understand motivation. A goal orientation represents an integrated pattern of beliefs that leads to "different ways of approaching, engaging in, and responding to achievement situations" (Schunk, Meece, & Pintrich, 2012). Historically, the most classic differentiation is between mastery goals and performance goals. Mastery goals focus on learning and mastering the task according to self-set standards or self-improvement, developing new skills, improving or developing competence, trying to accomplish something challenging, and trying to gain understanding or insight, whereas performance goals focus on demonstrating competence or ability and how ability will be judged relative to others. The mastery goal has also been referred to as learning goal, task-involved goal, or task-focused goals, and the performance goal has been referred to as ego-involved goals and ability-focused goals. In recent years, researchers have increased the number of goals. For example, the difference between approach- vs. avoidance-orientations have been added (e.g., Elliot & Harackiewicz, 1996; Skaalvik, 1997). For example, a student could focus on outperforming classmates (i.e., performance-approach goals), or they could focus on not being worse than the class average (i.e., performance-avoidance goals). Other recent developments are reviewed in Vansteenkiste et al. (2014).

The achievement goal approach has been shown to predict important psychological and behavioral outcomes, such as resilience to failure, the use of deeper learning strategies, and choosing challenging tasks (Schunk et al., 2012). However, as the name "achievement goal orientation" suggests, this approach is fundamentally focused on achievement, which is mostly relevant to competence. The emphasis could be either developing competence (mastery) or demonstrating competence (performance), either conceptions of competence in a particular achievement situation or individual differences in schemas of personal achievement, but the commonality is the focus on how one's conceptions of competence, or the purpose and motivation behind achievement behavior, lead to behavioral and experiential outcomes (Kaplan & Maehr, 2007). As such, it is not directly concerned about the alienation vs. self-congruent growth tendency

issue raised in the humanistic tradition[1]. For example, although there is some degree of overlap (e.g., mastery-oriented students are more likely to have personal interest and identification for the achievement activity, compared to performance-oriented students; e.g., Sheldon & Elliot, 1998; Vansteenkiste et al., 2014), one may also easily find counter-examples where people strive for higher performance for reasons that are self-fulfilling (e.g., an Olympics athlete who considers it truly valuable and meaningful to pursue excellence and perfection in performance), and where people strive for mastery for reasons that are alienated (e.g., a student who would agree mastery is more important than superficial performance but nonetheless has to "master" knowledge under the pressures of high-stakes testing). In short, the achievement goal theory does not systematically address the role of autonomy or volition, which are a critical factor for motivation.

Summary

The purpose of this section is to briefly review historical and contemporary theories of motivation in education, to provide a contextualization of our choice of self-determination theory as the central theoretical framework. I have shown that before the 1950s, the perspectives on motivation was dominated by deterministic views. Behaviors were seen as energized by biological drives or shaped by environmental stimuli. In the 1950s, humanistic psychology finally emerged as a force that accounts for the orientation toward growth and development as a source of motivation, yet it fell short of testing the theories using empirical methods.

In the second half of the 20th century, in the awakening of the cognitive revolution, a few theories aimed to study motivation using cognitive terms. The expectancy-value theory focuses on one's evaluations of whether an activity is doable and whether it is worth doing, yet it does not consider the important differentiations within the "value" of learning, such that some "values" may be more congruent with the growth tendency. The attribution theory considers an important dimension of motivation, namely, if an individual perceives the outcomes as incontrollable, they will feel incompetent, helpless and amotivated. However, classic attribution theory did not further

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[1] Like attribution theory, here I only summarize the classic achievement goal approach, where the center is on mastery vs. performance, and more recently, approach vs. avoidance. There are minor alternative versions of this approach that incorporated the factor of autonomy vs. alienation (e.g., Maehr & Nicholls, 1980). These minor branches are more akin to SDT, but they are more systematically addressed and organized in SDT (Kaplan & Maehr, 2007).

differentiate another dimension of attribution that is closely related to the organismic growth tendency, namely, whether the behavior is perceived as caused by internal reasons or some external reasons alien to the self. The achievement goal approach concerns mainly what competence goals students hold toward their schoolwork, but not so much the "why" that concerns self-determination vs. alienation under their choosing those goals, which is an important dimension of motivation.

SDT inherited the humanistic tradition, in that it also sees human beings as fundamentally motivated by an inherent tendency toward growth and self-development. As such, it is suitable for studying the effects of these organismic growth tendencies in the educational context. Importantly, it aims to study such growth-oriented motivation using empirical methods. Therefore, SDT represents an extension of the humanistic theories into modern empirical motivational science, and it studies the "why" of students' learning behavior from a perspective that is not sufficiently addressed by other contemporary motivation theories, providing important incremental explanatory power.

Self-Determination Theory

In this part, I will provide an in-depth summary of self-determination theory, covering constructs that will be involved in my dissertation (i.e., self-determined motivation, basic psychological needs, and need-supportive context). This part will follow the structure of the sub-theories of SDT. SDT consists of six inter-related sub-theories, of which three are mostly relevant in the current dissertation, and will be reviewed herein.

Cognitive Evaluation Theory (CET).

CET was the first sub-theory that was formulated in SDT. It specifically deals with the factors that determine intrinsic motivation, which is a prototypical manifestation of the organismic growth tendency, because it represents the human organism's spontaneous efforts to explore the environment, integrate new experiences, and expand itself. In short, the main gist of CET is that the cognitive evaluation (as opposed to simple stimulus-reaction mechanisms proposed by behaviorism) determine whether one is intrinsically motivated in a behavior. The cognitive evaluations could be informational, controlling or amotivating, each having a unique effect on intrinsic motivation, depending on how they satisfy the psychological needs (especially autonomy and competence). Below I will review selected studies that support these propositions.

One of the very first studies of SDT was conducted by Deci (1971). In Deci's experiment, the participants worked on interesting puzzles. The experimental group received monetary reward for each puzzle they solved, while the control group did not. The experimental task was followed by the free-choice task, in which participants were left alone with additional puzzles, as well as other interesting activities. Results showed that the experimental group decreased significantly in their engagement in the puzzles in the free-choice task. In a second study, Deci also showed in a field experiment that newspaper headline writers decreased in their intrinsic motivation to write headlines, after a period of being paid to do so. These studies marked an inception of CET (or SDT at large), because it falsified behaviorism. According to behaviorism, monetary reward is a type of reinforcement, and hence it should increase the occurrences of behavior; if anything, monetary reward should be additive on top of the intrinsic reward that people have toward an activity. However, this study and a few others that quickly replicated this one (e.g., Deci, 1972) clearly showed an undermining effect of monetary reward on intrinsic motivation. As such, these experiments support the formulations of CET: External rewards make people experience the rewarded activity as something they do for the rewards. This could prompt a change in perceived locus of causality (PLOC) from internal to external. That is, the activity that was perceived as caused by themselves (done for its own sake, for its inherent satisfactions) are now perceived as caused by some external forces (being controlled by the rewards). This thwarts the need for autonomy.

Besides monetary reward, the effects of positive feedback on intrinsic motivation is another area where CET is heavily tested. Positive feedback, or also referred to as praise or verbal reward, could take various forms, including telling people that they did well at the activity. Research has generally shown that positive feedback led to people displaying more intrinsically motivated behavior in the free choice period (e.g., Deci, 1971; 1972b; Deci, Cascio, & Krusell, 1975). CET explains such phenomena as follows. First, positive verbal feedback does not involve tangible rewards, nor is it usually revealed to the participants ahead of time such that they participate in the activity to get the verbal reward. Therefore, it is much less likely that the participants engage in the activity feeling controlled. In other words, their perceived locus of causality of this behavior is still internal to themselves, as opposed to being alienated (the case in monetary reward). As such, the need for autonomy is less likely to be thwarted. In addition, positive feedback also makes participants feel more competent.

Over the course of CET research, the multitude of empirical findings regarding what increases and what decreases intrinsic motivation have led to some consistent patterns. For example, monetary rewards do not always undermine intrinsic motivation, but it depends on how the monetary rewards are administered. If the monetary reward is administered in an undifferentiated manner (e.g., just for showing up in the experiment; e.g., Deci, 1972a), it will not undermine intrinsic motivation. On the other hand, some forms of verbal feedback will undermine intrinsic motivation, if they make people feel evaluated. For example, Smith (1975) showed that, if participants expect that they will be evaluated after the activity, they will display lower intrinsic motivation afterwards, even if they did get the positive effect.

From this diverse array of results (for a meta-analysis, see Figure 1 in Deci, Koestner, & Ryan, 1999), as well results derived from research that was conducted on other external events than rewards (e.g., punishments, surveillance, competition, choice, and optimal challenge), one conclusion emerged: It seems that how events impact intrinsic motivation is determined by the specific ways of how those events are delivered. As such, the concept of functional significance was developed. It was proposed that each event has its functional significance, or psychological meaning, on three aspects. First, there is an informational aspect, which provides individuals information about how they are doing. This aspect contributes to intrinsic motivation by satisfying the needs for competence and autonomy. Second, there is a controlling aspect, which pressures people to think, feel, or behave in particular ways. The controlling aspect diminishes intrinsic motivation by thwarting the need for autonomy. Third, there is an amotivating aspect, which signifies incompetence for people to attain desired outcomes in the activity, and diminishes both intrinsic and extrinsic motivation and promotes amotivation. These three aspects of functional significance constitute the core of "cognitive evaluations" in CET.

Overall, from all these studies that examined different types of external events, the satisfaction and frustration of need for autonomy and competence emerged consistently as central organizing principles that could parsimoniously and powerfully explain how an external event may impact intrinsic motivation. That is, an external event will increase or decrease intrinsic motivation to the extent that it satisfies or thwarts the needs for autonomy and competence.

The research reviewed above concern the CET investigations on how external events impact intrinsic motivation. CET also concerns itself with how interpersonal and intrapersonal contexts impact intrinsic motivation. Consistent with external events, the impact of interpersonal

and intrapersonal events are also organized and explained using the principles of basic psychological needs.

One of the first studies on interpersonal context was conducted by Ryan & Grolnick (1986). They found that students' perception of the classroom climates being autonomy-supportive (as opposed to controlling) predicts higher intrinsic motivation, on both classroom and student levels. In contrast, if the interpersonal context is need thwarting (e.g., Bartholomew, Ntoumanis, Ryan, Bosch and Thøgersen-Ntoumani, 2011), the intrinsic motivation will be undermined. Interpersonal contexts also moderate the effect of the same external event on motivation (e.g., Ryan, Mims, & Koestner, 1983). For example, educational settings almost always necessitate some form of limits (i.e., students have to follow certain rules), but Koestner, Ryan, Bernieri, and Holt (1984) showed that the limits do not have to undermine intrinsic motivation, if the educator administer the limits in an autonomy-supportive manner. This way, the activity could both satisfy the need for autonomy and competence (by providing a structure).

What is different from the findings in external events, however, is that the effects of interpersonal contexts also depend on a third need, namely, relatedness. The effect of interpersonal relationships on intrinsic motivation has been documented in attachment theory (e.g., Bowlby, 1979). For example, research has shown that a secure attachment relationship between the child and parent can foster spontaneous exploration behaviors (e.g., Frodi, Bridges, & Grolnick, 1985). As another example, Bao and Lam (2008) showed that children would generally show decreased intrinsic motivation if the activity they engage in is chosen by their parents (rather than themselves); however, if children feel close to their parents, there is no such decrease.

In addition to interpersonal context, CET also examines the effect of intrapersonal context. People sometimes internalize social influences around them. Therefore, just as interpersonal contexts could be controlling, people sometimes experience internal control that they administer to themselves. For example, people are sometimes self-evaluative, judging themselves and putting themselves "on trial". This is also termed ego involvement (as opposed to task involvement), because people feel that their self-worth is at stake. Thus, consistent with previous reasoning for interpersonal contexts, such internal judgment or ego involvement should also undermine intrinsic motivation because it diminishes the feelings of autonomy. This proposition has also been supported. For example, Ryan (1982) induced ego involvement by telling participants that the experimental task is reflective of creative intelligence. These participants ended up showing

significantly less intrinsic motivation than those in the task-involvement condition. A meta-analysis of 23 experiments (Rawsthorne & Elliot, 1999) also confirmed that ego involvement and performance goal manipulations led to significantly less subsequent intrinsic motivation.

The last note about CET is that considerable research has supported the positive role of intrinsic motivation on behavioral and psychological outcomes. These outcomes include greater conceptual learning (e.g., Grolnick & Ryan, 1987), performance (especially on "heuristic" activities; McGraw, 1978), and creativity (e.g., Amabile, 1983).

In sum, initial CET research on the role of monetary reward was able to falsify behaviorism and establish cognitive evaluation principles that determine intrinsic motivation. Subsequent research on of various types of external events led to the condensation of basic psychological needs (especially autonomy and competence) as the core explanations of intrinsic motivation. These principles are extended to and replicated in research on the impact of interpersonal and intrapersonal contexts.

Organismic Integration Theory (OIT).

In the preceding section I reviewed CET, the first theory formulated within SDT, which explains the psychological determinants of intrinsic motivation using terms of cognitive evaluation. Although intrinsic motivation is the prototype of the organismic growth tendency, one should be well aware of the fact that humans are social animals, and social life is replete with behaviors that are not intrinsically motivated, such as duties, chores, and sometimes work and studying. These behaviors are undertaken for reasons that are separable from those behaviors themselves (i.e., for an instrumental purpose rather than inherent interest). Therefore, they are termed extrinsic motivation. The gist of OIT is that extrinsic motivations differ in the degree to which they reflect the organismic growth tendency. For example, for a student who learns because they truly want to master the useful knowledge and skills, the learning behavior is in good congruence and harmony with other values and goals of this student, and the knowledge and skills are more likely to be assimilated and contribute to their psychological structure. In contrast, for a student who learns because they feel pressured by parents or teachers, the learning behavior is experienced as having an external locus of causality, and it feels alienated rather than being wholeheartedly endorsed. Therefore, their learning may not contribute to their integrated psychological growth and development as much. Note that in both these cases, the behavior is not

enacted for intrinsic interest (i.e., both are extrinsic motivation), but still they have important differences in terms of how much they are congruent with the integration and growth tendency in humans. Extending the insights gained from the study on intrinsic motivation (CET), OIT aims to also explain the extent to which the extrinsic motivation is internalized and integrated (and hence congruent with the organismic growth tendency) using the principles of psychological needs. In the following, I will review the four types of extrinsic motivation, which reflect differing levels of integration and internalization.

The most studied type of extrinsic motivation is external regulation. A behavior is externally regulated if it is motivated by and dependent upon external reward or punishment contingencies. For example, a student studying because he or she wants to avoid being punished by parents, or they want to get praise of teachers. The perceived locus of causality is completely external to the self (i.e., the behavior is perceived as caused by external contingencies). This type of regulation can actually be quite powerful motivating behavior in the immediate sense; however, because the behavior is not integrated at all, it will suffer from poor maintenance and transfer, because once the contingency is non-existent, people will not keep engaged.

The second type of extrinsic motivation, which is slightly more internalized, is introjected regulation. Introjection is a type of internalization that involves taking in or adopting a regulation or value, yet doing so in a way that is only a partial and incomplete transformation or assimilation. Phenomenologically speaking, an introjected behavior is associated with feelings of internal conflict, or being internally compelled, demanded or pressured, although it is initiated and regulated by the person him- or herself. In the negative form, it is experienced as the feelings of guilt or shame if one does not engage in the behavior; in the positive form, it is experienced as compliance with internal demands to engage in the behavior, for experiences of pride or self-esteem. Although this regulation is perceived as coming from the person him- or herself, and thus freed up from purely external contingencies (like in external regulation), it is still poorly integrated, in that the introject is not in harmony with the person's inner world. In this sense, the locus of causality of introjected behavior is perceived as internal to the person but external to the self. Therefore, the perceived locus of causality is slightly external (Figure 4). An example of introjection in education is a student studying because she or he wants to receive generalized approval or positive self-image, while avoiding feelings of shame or unworthiness if they do not perform well on learning tasks.

Behavior	Nonself-determined					Self-determined

Type of Motivation	Amotivation	Extrinsic Motivation				Intrinsic Motivation

Type of Regulation	Non-regulation	External Regulation	Introjected Regulation	Identified Regulation	Integrated Regulation	Intrinsic Regulation

Locus of Causality	Impersonal	External	Somewhat External	Somewhat Internal	Internal	Internal

Figure 4: The Self-Determination Continuum
Copied from Deci & Ryan (2000).

An even more internalized type of regulation of extrinsic motivation is identification. Identification is defined by a conscious endorsement of values and regulations. Thus, people who behave out of identified extrinsic motivation would say the behavior is important, or that it is personally valuable for themselves. Thus, the perceived locus of causality is internal to the self (i.e., the behavior is perceived as caused by the integrated self, more than by external forces). In the educational example, a student studies because she or he thinks the materials are useful to master for life and/or for their career development purposes.

Although identified behavior is assimilated into the self, and enacted with a sense of volition, it still does not imply that the behavior is fully compatible or integrated within the self. That is, although people identify with the activity itself and recognize its personal value, it still may not have been examined in relation to other aspects of people's identity. In fact, it is possible for identified behavior to be compartmentalized. For example, although the student may feel learning is important, it may not be reconciled with the valuing of other aspects of their lives, such as building enjoyable relationships with friends, or taking the time to appreciate the Nature. Hence, when this student works on coursework on a sunny Sunday, he or she may experience conflicts or inconsistencies upon reflections of why he or she is not outdoors hiking with friends.

In order to fully internalize the behavior, it takes integrated regulation. Integration entails that the regulation of a behavior to be brought to a full congruence with one's self, such that it works in harmony with the person's other needs, values and goals. When achieved, it is experienced as a wholehearted endorsement of the behavior, with an absence of conflict with other abiding identifications. For example, the student studies not only because he or she values learning, but because they consider themselves as aspiring intellectuals, aiming to get into a good university. As the qualification exam is close, they wholeheartedly prioritize working on coursework over other activities that they typically consider important.

The four types of extrinsic motivation are organized along a continuum, as shown in Figure 4. As can be seen, intrinsic motivation, integrated regulation and identified regulation of extrinsic motivation are internal and self-determined; introjected and external regulation are non-self-determined. Another non-self-determined type of motivation is amotivation, or the absence of any motivation, whether intrinsic or extrinsic. If amotivated, the person lacks the intentionality to behave altogether. As is briefly touched upon in the CET section, this is usually due to thwarted feelings of competence, i.e., people feel that they are incapable of bring about desired outcomes, and there is no contingency between what they do and the outcomes they get.

This continuum model has received consistent support, for most of its parts (except integrated regulation). For example, a recent meta-analysis (Howard, Gagne, & Bureau, 2017) examined the correlation patterns between the six types of motivation, using data collected from 486 samples representing over 205,000 participants. Multidimensional scaling was used to visualize the relative position of these six types, using correlations between them as indicators of proximity. The results largely supported a continuum structure (Figure 5), except that integrated did not place along the continuum as predicted by theory (it does not substantively fall between intrinsic and identified).
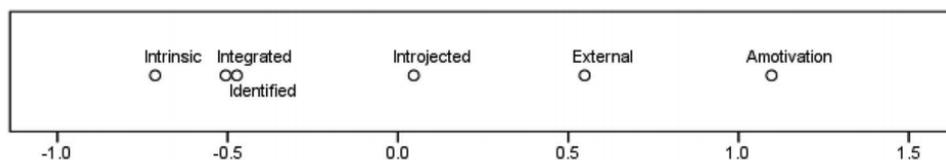

Figure 5: The Continuum Structure Revealed by Multi-Dimensional Scaling Using Meta-Analyzed Correlations

Copied from Howard et al. (2017).

Extending the findings from CET, OIT also proposes that the extent to which the extrinsic motivation is self-determined is determined by satisfaction of the basic psychological needs. Each of the three needs (i.e., autonomy, relatedness, and competence) is supposed to have unique and differentiated effects on the forms of regulation of extrinsic motivation. For example, competence is the most "basic" need for internalization, in the sense that if one feels incompetent in bringing about outcomes, one would be totally amotivated, and even external regulation could not occur. Relatedness is needed if the behavior is to be at least introjected, because introjection usually involves concerns for self-worth and others' approval. If one is in a social environment where no one cares about them and they care about no one else, the behavior would not be introjected as one wouldn't care. Finally, autonomy is needed if the behavioral regulation were to be self-determined. The person has to feel that the behavior is something personally valued and endorsed, something that they personally "take the ownership" of, as opposed to feeling that it is internal or external pressure that caused the behavior, to make identified and integrated regulation happen.

Unlike CET, OIT studies this proposition mostly using correlational and observational (as opposed to experimental) methods. As an example, one of the most studied contextual affordances that determine the internalization of extrinsic motivation is autonomy support. Autonomy support generally involve taking perspectives of other people, providing rationales for the required behavior, providing choices and minimizing control. Because autonomy support begins with taking others' perspective, it also likely allows the person who gives autonomy support to be more sensitive to competence and related needs of the other person. Therefore, autonomy support generally leads to higher satisfaction of all three needs. One of the earliest studies in OIT (Ryan & Connell, 1989) showed that children's perceptions of teachers' autonomy support are related to more internalized (more identified, in particular) academic motivation. As another example, Bartholomew et al. (2017) showed that controlling teaching (e.g., "My PE teacher shouts at me in front of others to make me do certain things") predicts lower self-determination in motivation for PE classes, via the mediation of the frustration of the students' basic psychological needs.

As a last note on OIT: Considerable research has also supported the important role of the internalization of extrinsic motivation for psychological and behavioral outcomes. Specifically, because internalized extrinsic motivation are perceived as volitionally endorsed by the self, it

usually is associated with higher quality and persistence of the behavior, especially for more difficult and complex activities. For example, Greenstein and Koestner (1996) showed that college students who had stronger intrinsic or identified motivations for their New Year's resolutions were more likely to have maintained the resolutions two months later, than those who had introjected or externally regulated extrinsic motivations. Also, because internalized extrinsic motivation is better internalized and congruent with the self, it causes less conflict and more positive experiences and psychological well-being. As an example, Ryan (1993) showed that Christians who engage in religious behaviors for introjected reasons suffered more from anxiety, depression, and somatization, whereas identified reasons were negatively related to these ill-being indicators. Identification was also positively related to self-actualization and esteem, whereas introjection was negatively related to these well-being indicators.

Basic Psychological Need Theory (BPNT)

As already discussed in the previous two sections, the construct of basic psychological needs was formulated in the process of conducting empirical research in CET and OIT. Throughout the previous two sections, it has been made clear that satisfaction of the three basic psychological needs (i.e., autonomy, relatedness, and competence) are essential for intrinsic motivation and the internalization of extrinsic motivation. In the current section, the focus is on BPNT, the sub-theory in SDT that specifically focuses on these needs and deals with the relationship between the BPNs and human wellness in general. To be sure, self-determined motivation is part of human wellness and optimal functioning. Because the effects of BPN on motivation has been discussed in the previous sections, in the current section I focus on the part of BPNT that explains the role of basic psychological needs for well-being, the inter-relationship between needs, and the role of autonomy support.

To understand the role of needs on well-being, it is first necessary to explain how well-being is conceptualized in SDT. Well-being has been a multifold construct. Colloquially, well-being is most often referred to as happiness. In psychology, happiness is specifically conceptualized as a subjective evaluation of one's life. That is, it allows each individual to have their own standards to evaluate their living: One could be happy as long as they subjectively feel good. This tradition is termed *hedonia*, which has been the most popular tradition in studying well-being, as seen in the research on positive and negative affects (Diener, 2000).

Yet another tradition that also has intuitive appeal is that sometimes we all know situations where feeling good does not mean wellness. For example, a patient with bipolar disorder at a mental clinic currently experiencing a manic upswing in mood is feeling very well, but it actually is a symptom of illness. A perhaps less pathological example: A student who has self-esteem strongly contingent on academic performance is currently experiencing a sense of self-aggrandizement and pride due to high performance on a recent test. One may also doubt if this student is high on wellness. Therefore, these cases suggest that there should be objective standards to determine whether one is living well. This tradition is termed *eudaimonia*, and it was established as early as in the philosophy of Aristotle (1869). Aristotle posited that "true happiness" is to be found in the expression of human excellence and virtue—that is, in the doing well of what is worth doing (Ryan, Curren, & Deci, 2013). In fact, the Greek term eudaimonia consists of roots of *eu* -- which means "good", and *daimon*, which means "spirit. Hence, it points to a positive state of being, or living in good congruence with one's inherent spirit or virtues. In *Nicomachean Ethics*, Aristotle asserted that the goal for life should be one that is both happy (i.e., subjectively pleasant) and expressive of what is truly worthy.

The SDT perspective on wellness is consistent with this multiplicate perspective. Hence, basic psychological needs are seen as essential aspects of human experience that determines optimal functioning and growth (i.e., eudaimonia). The role of basic psychological needs has been analogized to the role of physical needs for plants: Plants need sunshine, water and air as essential nutrients to physically well-function and grow. Like plants, humans have physical needs such as food and water; however, different from plants, humans also have psychological needs. As described in the previous sections, basic psychological needs are essential mechanisms that determines whether the human organism is spontaneously interested and engaged in exploring the environment (i.e., intrinsic motivation), and whether it successfully internalizes the values and behavioral regulations that are afforded by the ambient social environment (i.e., internalization of extrinsic motivation), both of which are the core of positive human function and psychological growth. Therefore, the satisfaction of the basic psychological needs is seen as essential to eudaimonia. On the other hand, hedonia is seen as the *symptom* of a eudaimonic living; when people are functioning well (i.e., living a eudaimonic life), they generally experience subjective happiness. Therefore, the satisfaction of basic psychological needs should also predict hedonic well-being. Hence, BPNT has been focused on empirically testing the hypothesis that the

satisfaction of basic needs lead to higher well-being, both relatively hedonic (such as subjective well-being) and more eudaimonic indicators (such as psychological health, self-esteem and vitality).

A complete review is documented elsewhere (e.g., Ryan & Deci, 2017). Here I briefly mention a few illustrative examples. One of the earliest studies that examined the effects of basic psychological needs on well-being is Ilardi et al. (1993). They found that the satisfaction (vs. frustration) of the needs for autonomy, relatedness and competence predicted well-being, as indexed by measures of self-esteem and general mental health. Researchers have also examined these effects on the within-individual level. For example, Sheldon, Ryan, and Reis (1996) measured the basic psychological needs and well-being and ill-being among college students everyday for two weeks. They found that not only do trait autonomy and competence predict indices of well-being (including positive affect and vitality) and ill-being (including negative affect and physical stress symptoms) that are aggregated over the two-week period, but also the daily fluctuations in the satisfaction of these needs predicted within-individual fluctuations in daily well-being. Recent research has pointed to the universal and cross-cultural validity of the conducive roles of BPN satisfaction (e.g., Chen et al., 2015; Yu, Levesque-Bristol, & Maeda, 2017).

BPNT also specifies the inter-relations between the three needs. Although the three needs are theoretically separately defined, they are seen as interdependent. Each need facilitates the satisfaction of the others under most conditions. For example, it is hard to derive competence satisfaction in an activity that one feels not autonomous or volitional; on the other hand, if one is not developing competence in the activity, one is also less likely to value or feel interested in the activity. Similarly, in a relationship that is controlling or non-autonomy-supportive, it is very hard to feel a sense of true interpersonal closeness; reciprocally, in a relationship that lacks closeness and intimacy, one is less likely to feel a sense of interest and willingness engaging in activities in the relationship. In short, although on a moment-to-moment basis needs may vary independently (e.g., one feels incompetent while performing a valued activity), SDT expects that the three needs will tend to be highly intercorrelated, especially in measurements that aggregate satisfaction or frustration experiences in a domain or over time.

Empirical support for the interrelationship between needs is mostly correlational. For example, a recent meta-analysis (Van den Broeck, Ferris, Chang, & Rosen, 2016) showed that the three needs are generally moderately correlated (r between .3 and .5). A few studies also shed

some light beyond correlations. Bao and Lam (2008) showed that children who are more related to their parents showed better motivational outcomes, given the same external condition of choice deprivation. This can be seen as a support that children who experience more relatedness satisfaction with parents also tend to experience more autonomy. On the other hand, the research by Hodgins, Yacko, and Gottlieb (2006) showed that when someone generally feel autonomous, they also tend to feel less defensive, and they may have a tendency to deem other's behaviors as less intrusive or threatening, and hence feel more related to others. This supports the link from autonomy to relatedness.

Although the three needs are inter-related, as mentioned earlier, on a moment-to-moment basis, it is possible to feel one need satisfied while other needs not satisfied. Some research have focused on such situations. As an example, in early research on intrinsic motivation, levels of competence and autonomy are each experimentally manipulated and self-determined motivation is observed (e.g., Ryan, 1982). One more recent study that scrutinizes such situations where the three needs are differentially satisfied is Sheldon and Niemiec (2006), where they examined the "balance" of satisfaction of the three needs. For example, a successful businessman may devote most his energy to his career, and he may experience high levels of competence because he is expanding his business; he is also likely to experience high autonomy because he feels like he is doing what he personally is identified with; however, he may not have the time to socialize if he is single, and he may need to sacrifice time with family if he is married. Another example is a new mother, who devotes most of her energy to taking care of the child, but puts aside the work she has, although that is what brings her a sense of achievement and self-actualization. Results from the four studies they conducted showed that people who experienced balanced need satisfaction reported higher well-being compared to those with the same sum score (sum amount of need satisfaction) who reported greater variability in need satisfaction.

BPNT also seeks to measure characteristics of the social environment and relate it to the satisfaction and frustration of the three needs. Relevant to the current study, the most-researched social style is autonomy support, which is usually characterized by being empathetic to others' feelings and thoughts, providing choices and minimizing interpersonal control, and providing rationales when asking others to do something (e.g., Deci & Ryan, 2000). Notably, autonomy support tends to contribute to the satisfaction of all three needs, but not only autonomy. As Vansteenkiste, Niemiec, and Soenens (2010) argued:

"When an individual truly understands another's internal frame of reference, the provided choice, information, and concern can be experienced as genuine, helpful, and caring. Thus, accurate empathy seems to be a precondition for supporting all three needs, which may explain why the three facets of need support strongly covary. Further, some elements of need support might satisfy a single need, whereas others might satisfy two or three needs. For instance, a meaningful rationale might help an individual grasp the value of an activity (autonomy support) and provide structure for the activity (competence support). Choice, however, would likely only satisfy autonomy. Thus, because there is no one-to-one association between need support and need satisfaction, the elements of need support are often highly correlated."

Therefore, the autonomy-supportive style also provides the basis on which other needs can be satisfied. In support, in the research by Ahmad, Vansteenkiste, and Soenens (2013), they found that parental responsiveness significantly positively predicted satisfaction of all three needs, whereas parental psychological control significantly negatively predicted satisfaction of all three needs. In this case, the shared parental context explains the covariance between the three needs.

METHOD

The purpose of the proposed study is to examine propositions derived from the General Model, using within-individual analytical methods, with a secondary college student dataset. In this chapter, I will describe the proposed research design, research context and participants, procedures of data collection and analysis, as well as the potential limitations of the proposed study. I will also describe potential threats to the validity of findings.

Research Design

The dissertation is a secondary data analysis of self-reported survey data. The data were collected from courses that were part of a campus-wide course transformation program (IMPACT) at the university where the study is carried out. Each semester, thousands of students voluntarily respond to online surveys asking about their experiences of the targeted course, including the need-supportive learning climate, basic needs satisfaction, self-determined motivation, etc., partly for their course evaluation survey. Course grade for these students are also available, obtained from the registrar. Because among the respondents some students were surveyed repeatedly (in different courses), over the last three years, we have accumulated a body of repeatedly measured students (up to seven semesters) that is sufficiently large to allow for within-individual analysis (Table 1)[2].

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[2] In the general within-individual research literature (e.g., Raudenbush & Bryk, 2002), within-individual analysis is considered pertinent as long as the responses are nested within individuals (i.e., one individual may provide multiple responses). The time lapse between repeated measurements varies greatly between studies, which could range from less than hours (e.g., Cote & Moskowitz, 1998) to years or more (e.g., Marsh et al., 2017). The key consideration is that the measurement time frame should match the level-1 unit that is of research interest. In the current study, the research question concerns within-individual and within-course experiences as the level-1 unit of analysis, and hence the corresponding time lapse between measurements could vary, depending on when the students respond to the surveys in the courses they took. Regardless of the time lapse, the data is still suitable for within-individual analysis.

Table 1: Overall Characteristics of the Dataset

No. of Responses per Student		1	2	3	4	5	6	>= 7	Total	Variance Explained by No. of Responses
Count of Students		11,625	4,441	1742	626	253	109	79	18,875	
Percentage of Students		61.59	23.53	9.23	3.32	1.34	0.58	0.42	100.00	
% Female		46.63	50.61	52.02	56.32	56.13	48.62	34.62	48.48	0.2%
Mean Age when Surveyed		20.30	20.03	19.91	19.88	19.87	19.77	20.04	20.18	0.5%
Mean	Learning Climate	5.34	5.35	5.40	5.41	5.27	5.39	5.45	5.35	< 0.1%
	Competence	4.56	4.57	4.62	4.62	4.57	4.56	4.59	4.57	< 0.1%
	Autonomy	4.60	4.60	4.64	4.70	4.63	4.68	4.72	4.61	< 0.1%
	Relatedness	4.73	4.76	4.81	4.82	4.76	4.78	4.85	4.75	< 0.1%
	Intrinsic Motivation	4.09	4.08	4.13	4.12	3.98	4.02	4.09	4.09	< 0.1%
	Integrated Regulation	4.95	4.97	4.95	4.99	4.94	4.90	5.11	4.96	< 0.1%
	Identified Regulation	4.81	4.84	4.90	4.92	4.83	4.87	5.02	4.83	< 0.1%
	Introjected Regulation	3.11	3.16	3.14	3.12	3.12	3.22	3.02	3.13	< 0.1%
	External Regulation	4.90	4.97	5.04	5.04	5.07	5.19	5.34	4.94	0.2%
	Amotivation	2.62	2.63	2.56	2.63	2.65	2.63	2.65	2.62	< 0.1%
	Learning Gains	3.64	3.65	3.66	3.66	3.57	3.66	3.68	3.64	< 0.1%
Median of Mean Personal Grades		3.30	3.50	3.43	3.43	3.40	3.38	3.28	3.35	< 0.1%

Data

The data that have been collected used convenient sampling. That is, all students enrolled in the undergraduate courses participating in the IMPACT program form the sampling frame of the current study. The IMPACT is a course transformation program over the campus that aims to achieve a greater student-centered learning environment by incorporating active and collaborative learning as well as other student-centered teaching and learning practices and technologies into large enrollment foundational courses. Each semester faculty members enroll in IMPACT, and via professional development sessions, redesign their courses to fulfill those goals. Students enrolled in these IMPACT courses will receive surveys that target their learning experiences, including the questionnaires that are used for the current research.

Therefore, with the IMPACT data, there may be under-coverage issues if the conclusions are to be generalized to the entire university student population. In addition, because response is voluntary, there may be some nonresponse bias, because the more conscientious, opinionated, or less busy students are more likely to respond. These biases are irreversible and are the limitations of the current study. Other limitations related to the threat to internal validity of this research is summarized at the end of the Method section.

There is no exclusion based on characteristic of students, but data screening was performed based on the quality of responses. Given that self-determined motivation is the central variable in this investigation, only participants who provided non-uniform responses to the 18 items of self-determined motivation are included in the analysis. 6,973 responses failed to produce a non-zero within-case variance for the 18 items of academic motivation, and are duly removed. This resulted in a dataset consisting of 30,765 responses (50.7% of 60,710, the total number of responses in the raw dataset), from 18,875 students (63.9% of 29,559, the total number of students in the raw dataset). Here I summarize the characteristics of the cleaned dataset, including sample sizes, demographics, as well as means of substantive variables in Table 1. It should be noted that these responses contain missing values. In the current study, all available data is used. This results in a *de facto* pairwise deletion approach in producing the estimates. The reason for this is partly because advanced missing data treatment methods (such as FIML) is technically unavailable for the type of model run; in addition, multilevel modeling generally handles different group sizes very well (Raudenbush & Bryk, 2002).

Table 1 shows the sample size, demographics, and descriptive statistics of the variables included in the original dataset. For example, the total number of responses in the dataset is 30,765, which was contributed by 18,875 students (Table 1). Most (11,625) students responded only in one classroom, but there are 2,809 students who responded in three or more classrooms (1,742+626+253+109+79 = 2,809). To examine whether the number of responses given by a respondent is systematically related to the respondent's demographic and substantive variables, the proportion of variance in the variables that can be explained by the number of responses, which is derived from regression model outputs, is reported in Table 1. As can be seen, the number of responses is not substantially related to most of the variables (i.e., it explained less than 0.1% of the total variance in those variables), except for gender, age, and external regulation. For gender, it seems that for the majority of respondents (i.e., respondents who responded 5 times or less), the more responses provided, the more likely that the respondent is female. This is somewhat understandable, because female students may be more agreeable and are more likely to help fill out voluntary surveys. For age, participants who provided more responses tend to have a lower average age when they are surveyed. This is reasonable, because students who are closer to graduation (i.e., older students) tend to have fewer chances to be surveyed, compared to younger students, who still have many future courses to take in college. As for external regulation, students' external regulation appears to increase with the number of responses they provide. Potential explanations for this are such as students who retake classes have higher external regulation, students who were in earlier cohorts tend to be more externally motivated, or students who are externally motivated tend to take more IMPACT courses, etc. Overall, the substantive variables do not seem to systematically change to the number of responses provided, but it is possible that the correlation between age, gender, external regulation and response counts may limit the validity of the findings.

Table 2 summarizes the number of responses each semester in the cleaned dataset.

Table 2: Number of Responses per Semester

	Frequency	Percent
Spring 2014	3,709	12.10
Fall 2014	3,824	12.40
Spring 2015	4,092	13.30
Fall 2015	8,431	27.40
Spring 2016	4,302	14.00
Fall 2016	2,706	8.80
Spring 2017	3,701	12.00
Total	30,765	100.00

Instrumentation

This research is completely observational (meaning the variables are observed, not experimentally manipulated), using a secondary dataset that includes self-report questionnaires and course grades. Below I include information about the data sources. The psychometric properties of the survey instruments are derived from an earlier compilation of the IMPACT dataset that contained 13,570 unique responses (this dataset has been also used in Yu & Levesque-Bristol, 2018, and Yu, Traynor, & Levesque-Bristol, 2018).

The Short-Form Learning Climate Questionnaire (LCQ)

This 6-item version of the LCQ (Williams & Deci, 1996) has been used to measure students' perceptions of autonomy-supportive classroom climate. Participants indicated the extent to which they agreed with the statements on a 7-point Likert scale (1 = *Strongly Disagree*, 4 = *Neither Agree nor Disagree*, 7 = *Strongly Agree*). An example item is: "I feel that my instructor provides me choices and options." Previous research has shown that the need-supportive learning climate measured by this scale is positively associated with satisfaction of all three needs (e.g., Yu, Traynor, & Levesque-Bristol, 2018). The internal consistency is high (alpha = .95). Three parcels will be created out of the six items (see data analysis section).

Academic Motivation Scale

This 18-item scale (Guay & Vallerand, 1996; Levesque-Bristol, Knapp, & Fisher, 2011) contains six subscales measuring the six types of motivation proposed by SDT (Deci & Ryan, 2000), with three items measuring each subscale. Among the six types of motivation, three are conceptualized to be self-determined (intrinsic motivation, as well as integrated and identified regulation forms of extrinsic motivation), and three are non-self-determined (introjected and external regulation of extrinsic motivation, as well as amotivation). The orienting statements ask students to indicate their "motivation for taking the course"; example items are "Because it's really fun" (intrinsic), "Because acquiring all kinds of knowledge is fundamental for me" (integrated), "Because it allows me to develop skills that are important for me" (identified), "Because I would feel guilty if I didn't" (introjected), "Because I feel I have to" (external), and "I don't know. I wonder if I should continue" (amotivation).

Participants indicated the extent to which they agreed with the statement on a 7-point Likert scale (1 = *Strongly Disagree*, 7 = *Strongly Agree*). The internal consistency is high for all subscales (Cronbach's alpha ranged from .84 to .96). Three parcels will be created out of the 18 items, each being a computation of self-determination index (SDI), using six items in the scale. Considering recent research findings (e.g., Sheldon, Osin, Gordeeva, Suchkov, & Sychev, 2017; Yu & Levesque-Bristol, 2018), the unweighted SDI will be used. That is, each parcel is computed using the formula intrinsic + integrated + identified - introjected - external - amotivation. For example, parcel 1 is computed using intrinsic1 + integrated1 + identified1 - introjected1 - external1 - amotivation1, i.e., a computation using the first item in each of the six subscales.

Inspection of the distribution of academic motivation suggested that many respondents have indicated the same value for all the items in this scale. Therefore, participants for whom the within-individual variance between responses for all the self-determined or non-self-determined items is 0 are removed from the dataset to avoid contamination of the dataset by careless responses. 6,973 (18.5%) of the raw dataset is removed for this reason, leaving 30,765 valid cases in the dataset.

Basic Psychological Needs Scale (BPNS)

We slightly adapted the 21-item BPNS (Ilardi, Leone, Kasser, & Ryan, 1993) to reflect the classroom setting in order to measure the satisfaction of the basic psychological needs for autonomy, relatedness, and competence. Examples of items are "I feel like I can make a lot of inputs in deciding how my coursework gets done" (autonomy), "People in this course care about me" (relatedness), and "I often do not feel very capable in this course" (competence, reversed). Participants indicated the extent to which they agreed with the statement on a 7-point Likert scale (1 = *Strongly Disagree*, 7 = *Strongly Agree*). Consistent with prior research (e.g., Yu, Traynor, & Levesque-Bristol, 2018), the item "There is not much opportunity for me to decide for myself how to go about my coursework" did not have a sufficient correlation with the other items in the autonomy subscale, and is hence removed from calculating the autonomy scale score. The Cronbach's alpha coefficients are satisfactory for all subscales (.76 for competence, .85 for relatedness, and .72 for autonomy). For each need, the items will be computed into three parcels.

Self-Assessed Learning Gains

This 5-point Likert scale measures participants' self-perceived gains in learning knowledge and skills identified by the faculty teaching the class surveyed. The questions were presented in the end-of-semester course evaluation. Notably, only about half the responses are paired with the perceived learning gains measurement. That is, among the 30,765 responses provided by a specific student for a specific course, only 15,520 contained self-assessed learning gain data. The questions share the same structure, "This course helped me learn/acquire _____ knowledge/skills," but the specific knowledge/skills that fill in the blank vary by course. For example, the knowledge/skills for a statistics class could include "calculating probabilities under the normal curve", and the knowledge/skills for an educational psychology class could include "understanding Bloom's Taxonomy". For each course, the number of perceived learning gains items used ranged from 3 to 8. In the current study, we are not interested in the specific knowledge or skills demonstrated in each class; rather, we are interested in how students perceived their gains in the knowledge or skills generally considered important by the instructors. Therefore, we averaged all the items and aggregated them into one self-assessed learning gains score to reflect a general level of perceived learning gains. We also calculated Cronbach's alpha, using all the available items and responses

on the self-assessed learning gains scale. The overall Cronbach's alpha was .93. This means that if we look beyond the differences of the specific knowledge/skills that the items target and treat them all as items that assess the general perception of learning gains, the items strongly correlate with each other. Self-assessed learning gains also had a weak positive correlation of .19 with course grade ($p < .001$). On the one hand, the high alpha and weak correlation coefficient with course grade provide evidence for the reliability and validity of the self-assessed learning gains measure; on the other hand, they also indicate that self-assessed learning gains are sufficiently different from course grades so that it may provide incremental value as a more subjective measurement for learning performance.

Course Grades

Course grades were obtained from the registrar. The distribution of grades showed a strong negative skew (skewness = -1.36, SE = 0.01; kurtosis = 1.60, SE = .03). After inverse transformation (Tabachnick & Fidell, 2001), the skewness is reduced to -0.123, but the kurtosis is still high (-1.57). Nevertheless, this should not substantially threat the validity of the current analyses, given that research has shown multilevel SEM to be generally robust against normality violations (e.g., Norman, 2010; Zhang, 2006).

Time and Dosage

For our first supplemental research question, we use time to predict perceived autonomy support and motivation. The time variable is based on the chronological order of the semesters that the data are collected, as shown in Table 2. For example, if the data is collected Spring 2014, the time variable has a value of 1. In addition, I also try to specify a dosage variable, which is closely related to time. Dosage is the number of IMPACT courses that the student has taken before. Estimating the effects of time and dosage on learning climate and motivation simultaneously could potentially disentangle the temporal trend into purely time effects and the effects of number of IMPACT courses taken before.

Majors

College majors will be used for one of the supplemental analyses, to examine if different majors moderate the effect of time. The majors of the current sample appear to be generally

proportionate to the major composition of the Purdue campus[3]. Following the procedure of a previous research project (Yu & Levesque-Bristol, 2018), the majors are coded into seven categories. The distribution of majors in the current sample is: 11565 (37.6%) engineering/technology, 2493 (8.1%) natural sciences, 4484 (14.6%) business/management/finance, 1491 (4.8%) social sciences, 340 (1.1%) humanities, 3469 (11.3%) other sciences (e.g., food science), 6910 (22.5%) other majors (e.g., nursing), and 13 (< 0.1%) missing. For the modeling of the moderation effect on time, consistent with previous studies (Yu & Levesque-Bristol, 2018; Yu, Zhang, Nunes, & Levesque-Bristol, 2018), the majors are grouped into three big groups: Social Sciences/Humanities, Business/Management/Finance, and All Others (which included engineering/technology, natural sciences, and other science or non-science majors). Two dummy variables are created, with the All Others group assigned as the control group.

Data Analysis

As previously mentioned, the current research will use cross-classified multilevel SEM. The analyses will be performed in the *Mplus* software (Muthen & Muthen, 2004). The data will be analyzed generally with four steps. First, preliminary analytical procedures will be performed to ensure that the data conform to general assumptions for multivariate analyses; second, preliminary multilevel analyses are performed, to ensure the data meet the requirements (specifically, the clustering effects are large enough) for multilevel modeling; third, the main model as shown in Figure 3 will be performed; fourth, the paths in the model run in the third step are allowed to vary across individuals and classrooms, to estimate the random effects in the model. The details of these steps are delineated below.

Step 1: data preparation and basic statistics. First, the distributions of raw items will be examined for univariate and multivariate normality and outliers. As already specified in the Data section, irresponsible responses (i.e., all items bear the same response) have caused irregular

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[3] There is no openly accessible data for the majors of all Purdue undergraduate student population, so it is impossible to accurately compare the major composition in the current sample with the actual population. However, judging from the number of students enrolled in different colleges (available at https://www.admissions.purdue.edu/academics/enrollment.php), it can be seen that the major composition in the current sample is generally proportionate to that in the student population.

distribution of the self-determined motivation. After removing these irresponsible respondents (6,973, or 18.5%; see the Data section for more details), the distribution of self-determined motivation became normal. Sample sizes of this screened dataset with reference to the number of responses each student provided are shown in Table 1. Although I will use all the available data, Table 1 shows that more than two thousand participants have provided three or more responses, which suggests a relatively adequate power to examine within-individual relationships.

Then, scale scores will be calculated from the raw items. Basic psychometric analyses will be conducted on the items to support the reliability (e.g., Cronbach's alpha) and validity (e.g., correlations) of the measures. Bivariate scatterplots will be run on these variables to visually scan for violations of normality, linearity and constant variance assumptions.

Step 2: multilevel clustering effects. One preliminary condition for conducting any multilevel modeling is to examine the clustering effect, i.e., how much do within-cluster (the clusters being both individual students and classrooms) responses correlate with each other, and how much variance is explained by between-cluster effects (e.g., Raudenbush & Bryk, 2002). The intraclass correlation coefficient (ICC), including ICC1 and ICC2, as well as the design effect, are ways to evaluate the clustering effect. According to Bliese (2000), Marsh et al. (2012) and Stapleton (2013), ICC1 evaluates the average correlation between responses within the cluster, and is sometimes referred to as the single-rater reliability. In *Equation 1*, τ_{00} is the level-2 variation, and σ^2 is the level-1 variation. In contrast, ICC2 takes into account the number of responses within clusters, and is an evaluation of the reliability of cluster mean. In *Equation 2*, n is the average cluster size. Just analogous to Cronbach's alpha, for which even low inter-item correlations could result in high scale reliability when there are a large number of the items with the same quality in the scale, the ICC2 could be high when ICC1 is low, if there are enough responses within each cluster. If both ICC1 or ICC2 is close to 0, then there may not be sufficient clustering effect, and it is not necessary to conduct multilevel analysis. There is no commonly agreed upon rule of thumb on the cutoffs for ICCs, although from a statistical point of view ICCs lower than .10 may cause estimation difficulties (e.g., Brunner, Keller, Wenger, Fischbach, & Ludtke, 2017). The *design effect* (*Equation 3*) is another indicator of clustering effect similar to ICC2, in that it is also a function of ICC1 and cluster size. It has been suggested that a design effect larger than 2 signifies substantial clustering effect that is of interest to multilevel modeling analysis (Muthen, 2004).

$$ICC1 = \tau_{00}/(\tau_{00} + \sigma^2) \tag{1}$$

$$ICC2 = n*ICC1/[1+(n-1)*ICC1] \tag{2}$$

$$\text{Design effect} = 1 + (n-1)*ICC1 \tag{3}$$

Step 3: main cross-classified multilevel SEM analysis.

After the multilevel nesting effect is validated, I proceed to using multilevel SEM to examine the substantive research questions. That is, the model that is shown in Figure 3 will be examined. All variables will be standardized, in consistency with prior research (Marsh et al., 2012).

The main model will first be examined using latent variables. In other words, the variables of learning climate, basic needs, motivation, and perceived learning gains will be regarded as latent variables, and they are defined using manifest indicators, on the within-student within-classroom level. Given that the current project is less interested in examining the psychometric details of these scales, but rather focus on the structural paths, we will adopt a parceling strategy, in which each latent construct is composed of three parcels (Little, Cunningham, Shahar, & Widaman, 2002). Specifically, we will use a domain-representative strategy, by forming parcels from the average of items taken from subscales. For example, each of the self-determined motivation parcel is formed by subtracting three non-self-determined items from three self-determined items (see SDI equation for the Academic Motivation Scale). Alternatively, if the latent measurement model fits poorly, i.e., if the parcels do not contribute to the latent variables as expected, then path models will be applied to examine the main model, in which all the variables are represented by one manifest indicator on the within-student within-classroom level. On classroom and student levels, these variables are latent and are defined by the one manifest indicator on the within-student within-classroom level.

Bayesian estimation is used, because it is the only estimation method available currently in Mplus for cross-classified models. The Bayesian method differs from traditional frequentist methods, which needs to be briefly explained. In traditional frequentist methods, the sample estimate (i.e., information derived from data) is used to infer the population parameter. In Bayesian methods, a prior distribution of parameter is also taken into consideration, such that the prior distribution and the information that is derived from the data (i.e., likelihood of data given prior distribution) are combined by taking their product to determine the posteriori distribution of a parameter (Figure 6).
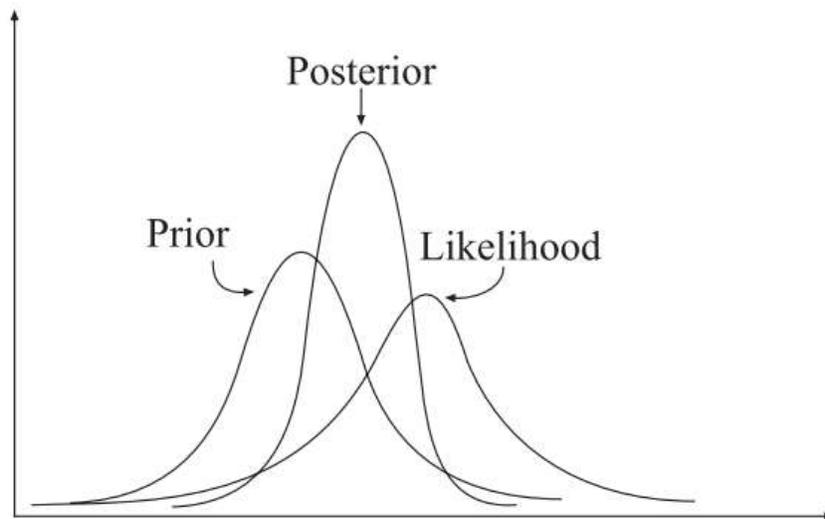
Figure 6: Prior, Likelihood, and Posterior for a Parameter
Copied from Muthen & Asparouhov (2012).

In the current study, consistent with previous conventions of using Bayesian methods (e.g., Muthen & Asparouhov, 2012; Asparouhov, Muthen, & Morin, 2015), the paths that are estimated (Figure 3) are set as having uninformative priors (i.e., with infinite variances), which essentially would yield the same estimate results as the traditional frequentist methods; the paths that are not expected to exist (i.e., the connections that are not drawn in Figure 3) are set as having small-variance informative priors, conforming to a distribution of $\sim N(0, 0.01)$. All the variables are standardized, to ensure that the priors are set to a standardized scale for the loadings. This essentially means that 95% of the standardized loadings are expected to fall between -0.2 and 0.2, which is considered small. Such a setting is considered as more flexible and realistic than the exact zero setting for cross-loadings and non-hypothesized structural paths, which is used in traditional SEMs. Using these settings, the posterior distribution of all parameters (not only hypothesized but also those that are not hypothesized) will be reported.

Fit of the models is examined using the posterior predictive *p* values (PPP). PPP around .50 is considered good fit. The lower the PPP is, the poorer the fit. PPPs lower than .05 indicate poor fit (Muthen & Asparouhov, 2012). The deviance information criteria (DIC) is also reported. The DIC can be used to compare the fit of two models (smaller DIC indicates better fitting model).

Step 4: evaluating random slopes. The previous steps produce a model that provides estimates of the within-individual within-classroom relationships (thickened arrows shown in Figure 3). However, to answer the question of whether these relationships vary significantly across individuals and classrooms, we need to examine random variations to the path loadings (slopes). The variance of the random slope term can be evaluated against its standard error to determine whether the slopes significantly vary across individuals or classrooms. If the random slope is significant and retained in the model, then other variables may be added to predict the random slope. For example, major (as a between-individual level variable) will be used to predict the random slope of time → self-determined motivation, to examine whether students in different majors have different change trajectories of self-determined motivation.

Possibility of Model Estimation Difficulties

It should be noted that with the complexity of these models, it is likely that estimation difficulties will be encountered. In the case that the model cannot be estimated, I will take a step back and take simpler approaches to the model. For example, if the full model specified does not successfully run, I may attempt to simplify the model, by running a cross-classified multilevel path model instead (without including level-1 latent variables), by specifying a measurement model (instead of full predictive structural equation models) at level-2, by reducing the number of variables (e.g., combining three needs into one overall need satisfaction), by using only the 2,809 respondents who provided three or more responses, or by reducing the number of paths estimated simultaneously.

Potential Limitations and Threats to Validity

First, as in most longitudinal designs, the effect of repeated measurement could result in a threat to internal validity to the *testing* of the research. Specifically, having responded on the motivational questions may change the response of participants in itself. For example, students who have responded to the questionnaires before may be familiar with the items, which makes them less attentive to the questions. As another example, it may even prime the participants to think about their motivations for their courses, which may have changed their decisions to take subsequent courses. Relatedly, because IMPACT in essence is a course transformation program (which have instructors that are more inclined to promote student-centeredness), it may have

positive effects on the course, so that the more students take IMPACT courses, the better their motivations will be -- this is termed the *dosage* effect. In the current research, the testing threat to internal validity is confounded with the dosage effect of taking IMPACT courses, and the combined effect of the two constitutes a limitation of the current design. This issue can be partially dealt with by including a covariate at level-1 that controls for the number of IMPACT surveys that the student has previously taken.

Second, there is a potential for *differential attrition* threat to internal validity. It was possible that students who provided more responses are different from those who provided fewer responses. For example, if social sciences students, who are generally more self-determined (Yu & Levesque-Bristol, 2018), are more likely to respond to IMPACT surveys, then the within-individual estimations may be biased to be more representative of these social science students. To remedy this threat, in my preliminary data analysis, I have shown (in Table 1) that there is generally no visible difference between those who provide more responses and those who provide less (except for external regulation). However, this could not completely rule out this threat, and differential attrition should be noted as a limitation for the current study.

Third, the multilevel SEM is still correlational in nature, and it is subject to *ambiguous temporal precedence* threat. In essence, the research could answer the question of how the variables covary and statistically predict each other, especially at the within-individual, within-classroom level; it does not answer the question of which variables cause which. One may find this confusing, because our data is longitudinal, containing multiple time-points per individual. However, it should be noted that, although the data is longitudinal, the main model is not. That is, the main research questions regard the covariation relationships between variables, within the same person, in a same classroom; in contrast, a longitudinal model will involve the relationship between one variable at one time-point and another variable at a later time-point. As such, the temporal precedence between any given two variables, within that same classroom for the same person, cannot be determined in the current model.

Fourth, the current design may also be affected by history and maturation issues. For history: Because the data is selected from fall 2014 to spring 2017, there may be a cohort effect that affects the different semesters. For example, will the election of President Trump have any effect on students' motivation for the spring 2017 semester? I can attempt to control for the cohort history effect by including a control variable (e.g., a set of dummy coding of cohort, added as

level-1 predictors). Maturation is actually actively modeled in the current research, because time will be linearly modeled at level-1, to examine the trajectory of motivation change. However, even with these methods, it should be noted that the history and maturation (and there may be an interaction effect of these two) effects cannot be completely accounted for, and should be noted as a limitation in the current research.

Fifth, there is a threat to the *instrumentation* aspect of internal validity. Specifically, the learning outcomes in the current research is measured by two variables: grades and self-assessed learning gains. Because the current research attempts to both reflect the course-specific learning outcomes, and cover a wide range of courses, it is inevitable that the measurements of learning outcomes vary across courses. Therefore, the instrumentation of learning outcomes is not completely comparable across courses, which potentially threatens the internal validity. Nevertheless, by considering covariates and nesting structures, these issues can be partially controlled for. For example, major is one specific factor that affects the grades norm, and it could be controlled for. Most importantly, with the cross-classified multilevel analytical approach, course and individual level variations can be accounted for to a large extent, so that the estimates at level-1 is net of the effect of different courses. In addition, it is worth noting that even without these corrections, previous analyses using this dataset (e.g., Yu & Levesque-Bristol, 2018) has found that at the between-individual level there is a positive association between grades and self-determined motivation. In sum, the instrumentation threat should not pose a serious problem to the current analysis.

RESULTS

Step 1: Basic Statistics

The correlations and internal consistency reliabilities are reported in Tables 3 and 4. It should be noted however, that the analyses reported in Step 1 is only for the general purpose of screening the data and examining the assumptions. These should not be taken as rigorous tests, because the nested structure of the data violates the independence assumptions for calculating correlations and internal consistency reliability. Nevertheless, it should be sufficient to provide a general sense of the data. For more rigorous tests of the substantive relationships between variables, I ran multilevel models, which are included in the succeeding steps.

As can be seen in Table 3, The variables are correlated in the expected pattern. Learning climate is strongly positively correlated with the three basic psychological needs; the three needs are strongly positively correlated with the three types of self-determined motivation, and negatively correlated with amotivation; the three types of self-determined motivation are strongly positively correlated with self-assessed learning gains, but only weakly positively correlated with grades; introjected external motivation and amotivation are weakly-to-moderately negatively correlated with grades and perceived learning gains. All the variables have good internal consistency reliability.

Histograms and bi-variate scatterplots are run to examine the general assumptions held for linear regression models (Figure 7). As can be seen, the multivariate normal distribution assumption is generally satisfied, except for grades, which showed a strongly skewed distribution. The skewness and kurtosis of all other endogenous variables (i.e., DVs and mediators in the model) are between -1 and 1, but grades had a skewness of -1.36 and kurtosis of 1.60. Therefore, an inverse transformation was performed (Tabachnick & Fidell, 2001). The inverse-transformed grades had low skewness (-0.123) but the kurtosis is still high (-1.57). The lack of normality of the grades variable is a limitation in the current dataset.

Besides skewness and kurtosis, several variables also appear to have slight range restriction effects (i.e., ceiling and floor effects). For example, by looking at the bivariate distribution scatterplot for LCQ and SDI (fifth plot from the left on the top row), it is apparent that the elliptical shape that the multivariate distribution is supposed to take is "truncated" at the top. This means

that the LCQ is insufficient in reflecting latent learning climate perceptions that are on a very high level. This finding is consistent with recent research on the psychometric qualities of the LCQ (Yu, Traynor, & Levesque-Bristol, 2018). Restricted range also seems to be a problem (although to a lesser magnitude) for the three basic psychological needs and the self-assessed learning gains. Truncated data does not reflect the relationship between variable on the full range; as such, the restricted ranges post a limitation for the current research.

For those pairs of variables that do show a relationship pattern (i.e., most variables except grades), the scatterplots show an elliptical pattern that suggest multivariate normality, and no "megaphone" shapes are observed. Therefore, the constant variance assumption should be met. The bivariate scatterplots also show that the relationships between variables is generally linear; no signs of curvilinear relationship is observed.

Table 3: Zero-order Correlations, Internal Consistencies and Non-Normality Statistics for Variables

	1	2	3	4	5	6	7	8	9	10	11	12
	LCQ	Com	Aut	Rel	Int	Itg	Idt	Itj	Ext	Amt	Grades_Inv	SALG
1		.58	.70	.35	.51	.38	.52	.05	-.09	-.36	.20	.50
2			.73	.50	.63	.43	.60	-.09	-.23	-.58	.33	.53
3				.50	.55	.39	.52	-.05	-.19	-.43	.28	.45
4					.32	.30	.35	-.07	-.05	-.33	.20	.27
5						.59	.78	.17	-.28	-.37	.19	.55
6							.72	.24	-.12	-.25	.10	.41
7								.20	-.20	-.43	.15	.57
8									.25	.31	-.07	.08
9										.22	-.07	-.15
10											-.18	-.38
11												.16
Alpha	.94	.75	.77	.85	.94	.81	.87	.85	.81	.81	NA	.93
M	5.36	4.58	4.62	4.76	4.09	4.96	4.85	3.13	4.98	2.62	0.70	3.65
SD	1.32	1.05	1.05	0.96	1.61	1.20	1.36	1.50	1.35	1.37	0.28	0.97
Skewness	-1.02	-0.27	-0.37	-0.07	-0.33	-0.65	-0.80	0.41	-0.61	0.86	-0.12	-0.63
Kurtosis	0.77	0.09	0.22	-0.08	-0.77	0.28	0.21	-0.70	-0.08	0.16	-1.57	0.20

Note. All correlations significant on $p < .001$ level. Com=Competence. Aut=Autonomy. Rel=Relatedness. Int=Intrinsic. Itg=Integrated. Idt=Identified. Itj=Introjected. Ext=External. Amt=Amotivation. Grades_Inv = inverse transformed grades. SALG = self-assessed learning gains. Sample size for SALG is approximately 15,000 instead of the total (approximately 30,000).
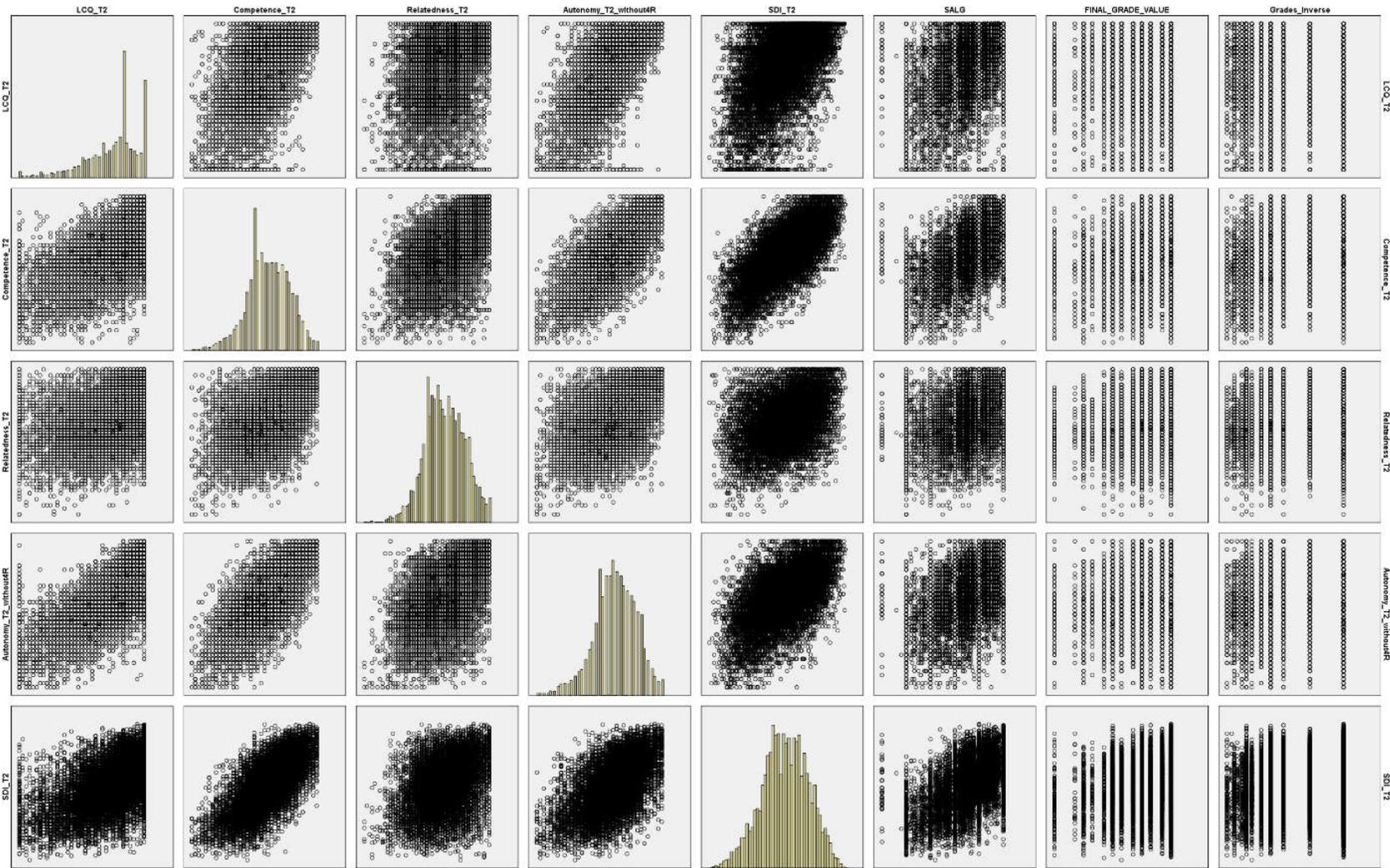
Figure 7: Distribution of Variables.
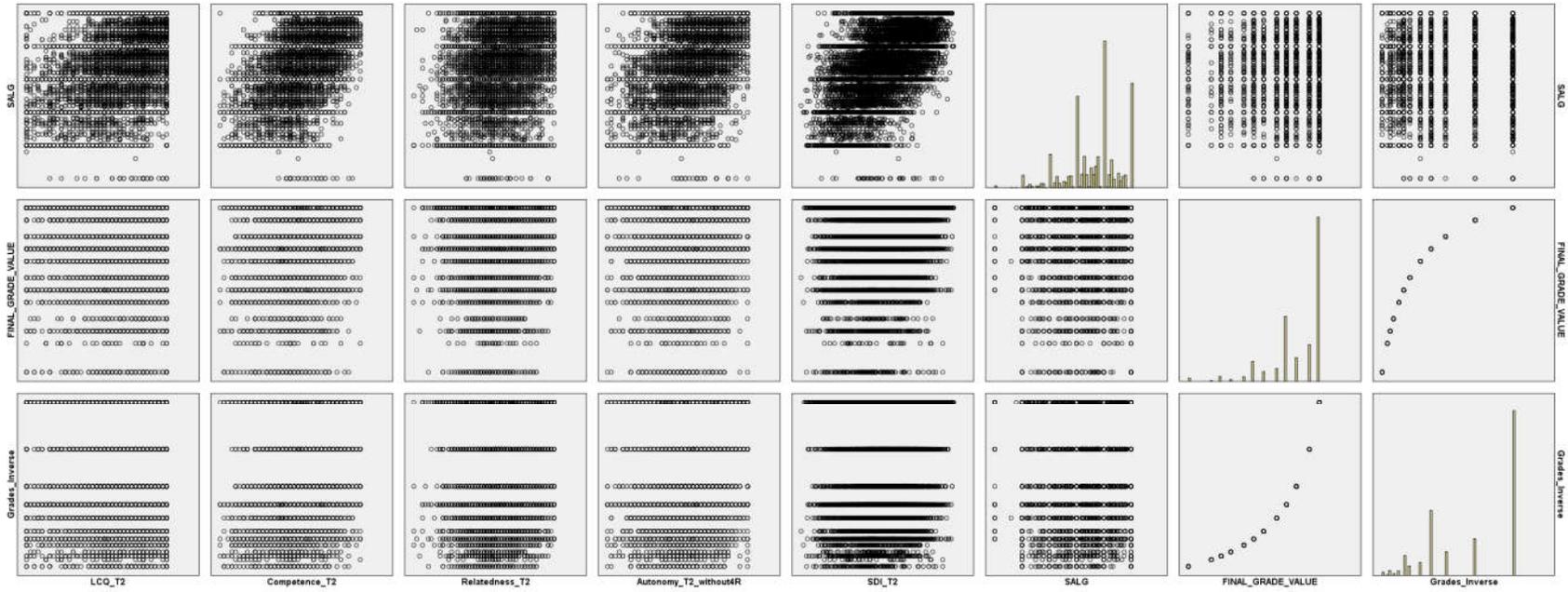
Figure 7 continued.

Step 2: Multilevel Clustering Effects

A summary of the clustering indices is provided in Table 4. As can be seen, the ICC1s are generally above .10, which means that above 10% of the total variance can be explained by either the classroom or the student nesting structure. Although conventional interpretation is less available for ICC2, it appears that ICC2s are also relatively high. The design effects show that the classroom nesting structure is especially substantial from a multilevel analytical perspective. Overall, these indices suggest that the data grant multilevel correction.

Table 4: Student (s) and Classroom (c) Clustering Effects on Variables

Variable	ICC1 (s)	ICC2(s)	Design Effect (s)	ICC1(c)	ICC2(c)	Design Effect (c)
Grade	.33	.44	1.21	.23	.79	3.67
Learning Gains	.22	.31	1.14	.16	.70	2.82
Intrinsic	.24	.33	1.15	.19	.75	3.24
Integrated	.48	.60	1.30	.06	.46	1.75
Identified	.30	.41	1.19	.15	.69	2.72
Introjected	.56	.68	1.35	.04	.36	1.50
External	.41	.53	1.26	.11	.60	2.23
Amotivated	.36	.48	1.23	.09	.56	2.08
Competence	.26	.37	1.16	.13	.66	2.54
Autonomy	.27	.38	1.17	.21	.77	3.45
Relatedness	.34	.46	1.22	.17	.71	2.93
Learning Climate	.20	.29	1.13	.25	.80	3.86

Step 3: Main Model

The main model to be examined is the relationship between the variables on all the levels. First, latent models in which the variables are defined by manifest indicators (e.g., the SDI is associated with three parcels) are specified.

Latent Measurement Model

The cross-classified CFA model, in which all the latent variables are correlated with each other, is performed. The purpose of this model is to examine whether the parcels contribute to the latent variables as expected, on all three levels. This model turned out to have poor fit: PPP = .000, DIC = 1375733.09. This indicates that the parcels function differently on different levels. In other words, although the three parcels for SDI may covary with each other on the individual level (i.e., individuals who score high on one SDI parcel also tend to score high on the other two SDI parcels, and the latent SDI variable is what explains the covariance), on the classroom level, classrooms that score higher on the class-aggregate SDI parcel one do not correlate with the other parcels of class-aggregate SDI in the same way. That is, the parcels on individual level and on an (classroom or student) aggregate level do not have the same latent meaning.

Path Model

Given the misfit of the latent model, I proceed to examine the main research questions using the path model method. In the path model, all variables are represented using one manifest variable. The path model had good fit: PPP = .451, DIC = 442600.70. The path loadings are shown in Figure 8. As can be seen, on the within-individual, within-classroom level, many of the hypothesized effects are supported. For example, the autonomy-supportive learning climate has significant positive effects on all three needs; autonomy and competence both significantly positively predict self-determined motivation, which then significantly positively predicts perceived learning gains. A few hypothesized effects are non-significant: Relatedness does not contribute to self-determined motivation, and grades are not predicted by any other variable. In addition, autonomy support also seems to have significant effects on self-determined motivation and perceived learning gains, and competence also has a significant positive effect on perceived learning gains.

On individual level, results are highly similar. Students who generally perceive higher autonomy support in the classroom also tend to perceive higher needs satisfaction. The only need that is significant in predicting motivation is competence, such that students who generally feel competent in classrooms also generally are self-determined toward taking those classes. Self-determined motivation significantly positively predicts higher perceived learning gains, but not

grades. There also appears to be direct effects of autonomy support on perceived learning gains and on motivation, such that students who generally perceive higher autonomy support also tend to have higher self-determined motivation and perceived learning gains across courses, beyond what can be accounted for by needs. Competence also has a significant direct effect on perceived learning gains.

On the course level, the effects are less expected and interpretable. First, it is consistent with the other levels that learning climate predicts needs satisfaction; in other words, courses that have higher aggregated student rating of autonomy support also tend to have higher aggregate student ratings of autonomy, relatedness, and competence satisfaction derived from this course. However, while the effect of competence on self-determined motivation is significant and positive, the effects of autonomy and relatedness on motivation are significant (though weak) and negative. Competence also has significant positive effect on grades, whereas self-determined motivation has significant negative effect on grades. Competence and learning climate have positive effects on perceived learning gains, whereas autonomy has negative effect on perceived learning gains.

One interesting observation is that, for the paths that are significant on both level-1 and level-2, the strength of these paths on the level-2s are generally stronger than the strengths on level-1. As an example, the relationship between learning climate and needs satisfaction are 0.28, 0.61, and 0.50, for relatedness, autonomy and competence respectively, on level-1, but these values are 0.53, 0.77, and 0.63 on the individual-level, and 0.35, 0.89, and 0.82 on the course-level.
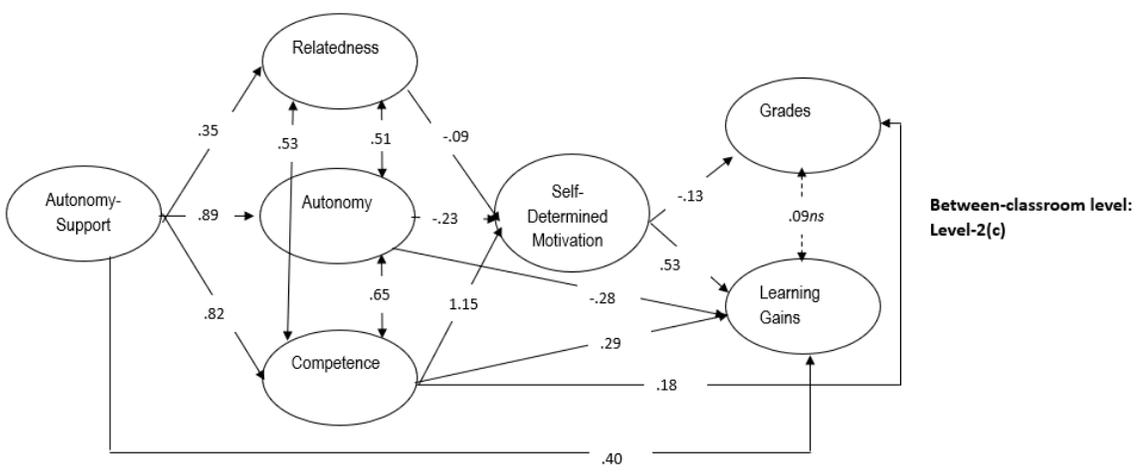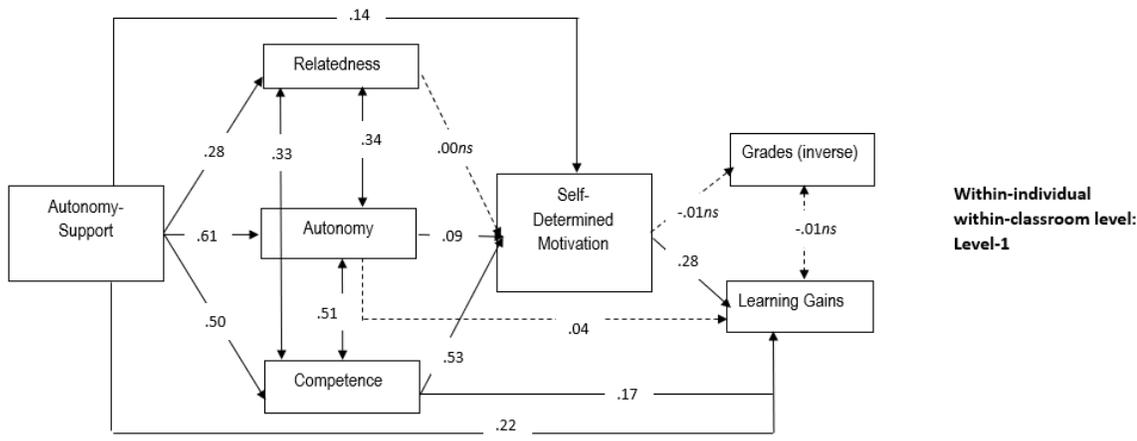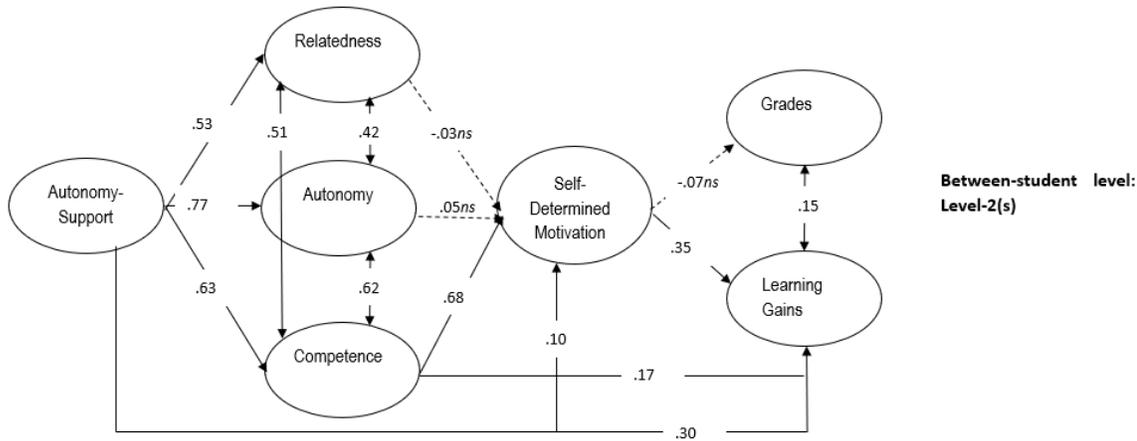
Figure 8: Results of the Cross-Classified Multilevel Path Model
All solid paths are significant at a *p* < .05 level. Dashed arrows are hypothesized or significant paths that are very weak (< .10). Relationships that are not shown on diagram are non-significant.

Suppressor Analysis

In the findings on the classroom level, although all the bivariate correlations are positive as expected, some of the regression coefficients are negative, whereas others are larger than 1 (e.g., the effect of competence on self-determined motivation). This phenomenon is called *suppression effect* (e.g., Maassen & Bakker, 2001). Using a regression example with two predictors positively predicting one outcome, suppression effects usually happen when there is a high correlation between the predictors (high multicollinearity), and the correlation of one predictor (say, x_1) with the outcome (y) is much higher than the correlation of the other predictor (x_2) with the outcome. When this happens, the weaker predictor's effect, after taking away the relatively strong indirect connection of x_2-x_1-y, becomes negative, and the stronger predictor's effect becomes stronger, sometimes stronger than 1 (Deegan, 1978). For x_2, this means that the "pure" effect of x_2 on y may be negative, and it is the fact that x_2 being highly correlated with x_1 (which is itself a positive correlate of y) that has "suppressed" the effects (with the suppression, the effect of x2 becomes more positive, and the effect of x1 becomes less positive).

When suppressor effect happens, it is suggested that one could identify the variables responsible for the unexpected negative predictive relationships (Maasen & Bakker, 2001). In the case of the current findings on the course level, three outcome variables demonstrated suppression effects: self-determined motivation, perceived learning gains, and grades. Because grades are only positively predicted by competence besides the negative loading of motivation, it is apparent that the strong association between competence and grades has suppressed the effect of motivation on grades. Similar for motivation: Competence is the only (and very strong) positive predictor of motivation, and the other needs have negative associations with motivation; thus, it is clear that the dominant effect of competence has suppressed the effects of autonomy and relatedness. For perceived learning gains, after removing the predictors one by one, I found that learning climate is responsible for the negative association between autonomy and perceived learning gains. After removing learning climate from the model, the negative relationship between autonomy and perceived learning gains disappeared. This is not surprising given the strong relationship between learning climate and autonomy ($b = 0.89$).

Alternative Model

The alternative model, which was raised in Levesque-Bristol et al. (under review), is also examined. The alternative model fits well: PPP = .446, DIC = 442324.00. This fit is very close to that obtained from the main model. On the within level, learning climate significantly predicts autonomy and relatedness, which in turn predict competence, which then predicts motivation, which then predicts grades and perceived learning gains. The path loadings of these effects are almost identical to those found in the original SDT General Model, with one exception: The direct effect from learning climate to competence need satisfaction becomes much weaker in the alternative model (Figure 9). The suppression effects are also observed in the classroom level of the alternative model. Because the fit is very close, the data favors the original SDT model and the alternative conception equally.
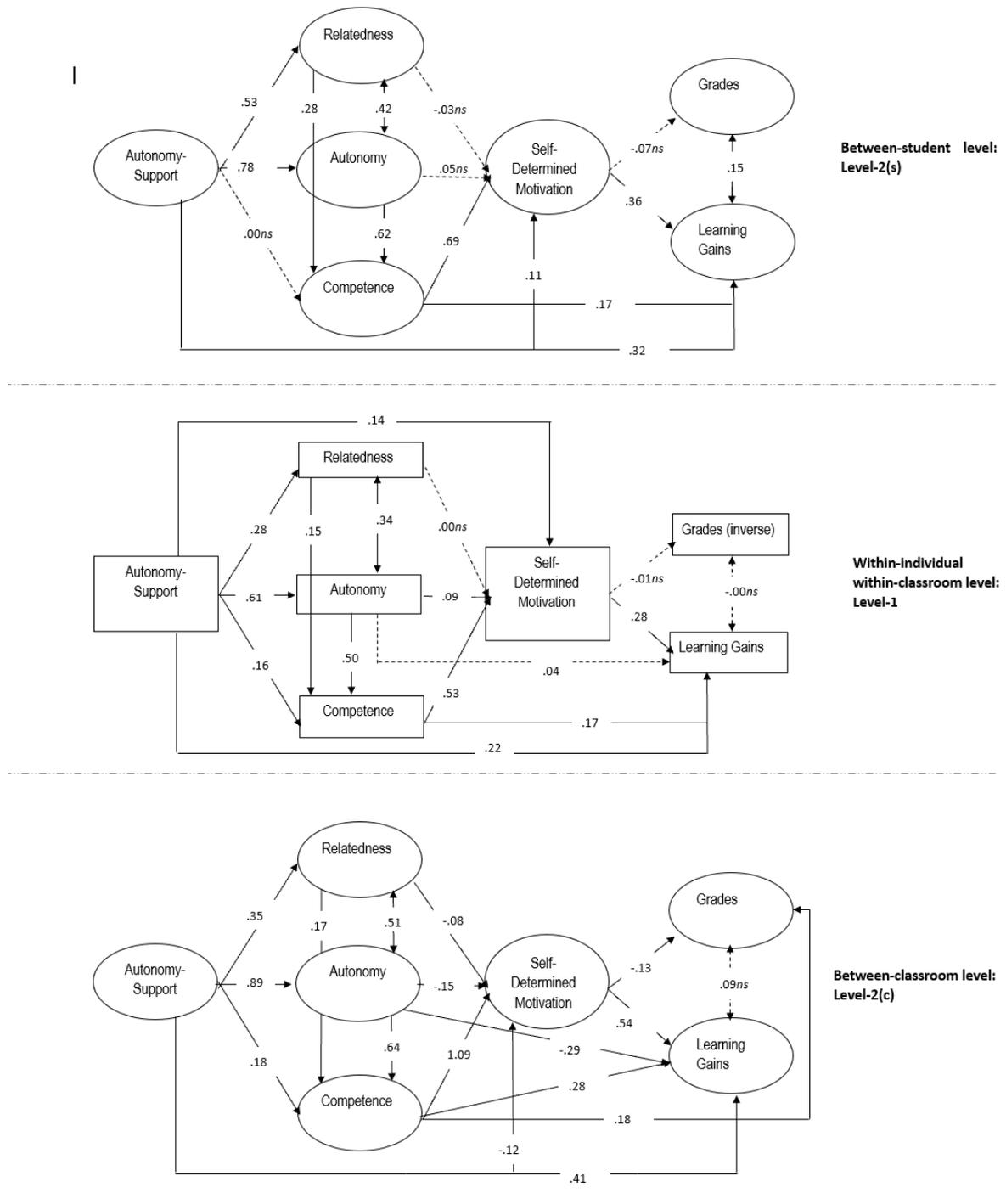
Figure 9: Results of the Alternative Model

All solid paths are significant at a *p* < .05 level. Dashed arrows are hypothesized or significant paths that are very weak (< .10). Relationships that are not shown on diagram are non-significant

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Step 4: Random Slope Models

Temporal Trends in Motivation, Basic Needs, and Perceptions of Learning Climate, and the Moderation Effects of Academic Majors

To examine the effect of time on motivation and learning climate, the time variable is added to the within level, as a predictor of learning climate and self-determined motivation. The model fits well (PPP = .50, DIC = 425989.23). The effects of time are non-significant on learning climate (standardized b = 0.020, SE = 0.009, p > .05), motivation (standardized b = 0.006, SE = 0.007, p > .05), autonomy (standardized b = -0.008, SE = 0.005, p > .05), and relatedness (standardized b = 0.006, SE = 0.009, p > .05). The effect of time on competence need satisfaction is significantly negative (standardized b = -0.014, SE = 0.005, p < .05). After adding random effects for the time effect, the results showed that, although the mean effects are non-significant, the effects of time on learning climate and on motivation have significant random variations across students (p < .001; both variance and SE are smaller than 0.001). This means that, although it seems that neither motivation nor the perception of learning climates is increased or decreased, there is substantial variation in such trends between students.

Hence, as the next step, I proceeded to examine whether the major that students are in may explain this student-level variation. Results showed: First, the intercepts of the random slopes are non-significant (for the effect on learning climate, intercept = 0.013, p > .05; for the effect on motivation, intercept = 0.001, p > .05). Because the intercepts are the random slopes' values when the predictors, or the major dummy variables, take the value of 0 (i.e., the Control Group, including engineering/technology, natural sciences, and other majors such as food science and nursing), this means that for the Control Group, the temporal trend of either learning climate or motivation is null, which is consistent with the fixed effects reported in the previous paragraph. Yet, consistent with previous research (e.g., Yu & Levesque-Bristol, 2018), the Business/Management/Finance group has a significantly deleterious effect on the temporal trend of both motivation (standardized b = -0.018, SE = 0.004, p < .001) and learning climate (standardized b = -0.020, SE = 0.004, p < .001), whereas the Social Sciences/Humanities group has a significantly conducive effect on the temporal trend of motivation (standardized b = 0.019, SE = 0.005, p < .001; but not significant on learning climates, standardized b = -0.001, SE = 0.007, p > .05).

Because the intercept of the motivation time trend is very close to 0 (0.001), this means that over time, students in the Social Sciences/Humanities group report significantly higher levels of self-determined motivation (0.001 + 0.019 = 0.020), whereas students in the Business/Management/Finance group report significantly lower levels of self-determined motivation (0.001 - 0.018 = -0.017). Because the intercept of the learning climate time trend is slightly positive (0.013), this means that over time, students in the Social Sciences/Humanities group report slightly higher levels of learning climate (0.013 - 0.001 = 0.012), whereas students in the Business/Management/Finance group report slightly lower levels of learning climate (0.013 - 0.020 = -0.007).

As the last step, the dosage effect is included alongside the time effect. Neither the main effect of time (standardized $b = 0.004$, $SE = 0.003$, $p > .05$) nor dosage (standardized $b = -0.001$, $SE = 0.001$, $p > .05$) is significant on self-determined motivation. However, there is a suppression effect on learning climate: When simultaneously estimating the effects of time and dosage on learning climate, the effect of time becomes significantly positive (standardized $b = 0.017$, $SE = 0.008$, $p < .001$; note that the effect of time only on learning climate is non-sig, as discussed in previous paragraphs), and the effect of dosage on learning climate is significantly negative (standardized $b = -0.005$, $SE = 0.002$, $p < .001$). This means that as students proceed in their college years, they are more likely to perceive classrooms as autonomy-supportive; however, the more IMPACT courses they took, the less autonomy-supportive they tend to perceive. Furthermore, the moderation effect of major on the effect of time on learning climate is replicated, such that even after controlling for dosage, results show that the temporal trend in perceived learning climate is significantly more deleterious in Business/Management/Finance majors (standardized $b = -0.017$, $SE = 0.005$, $p < .001$). There is no significant major moderation on the dosage effect.

Individual Difference Moderation

The second set of models test whether the relationship between needs satisfaction and learning climate at the within level vary across persons and classrooms, and whether the strength of this relationship is explained by the overall student-level perceptions. As specified in Step 4 of Data Analysis in the Method chapter, the first step is to run unconditional random slope models, in which the random terms are added to the effects of learning climate on needs satisfaction. However, only the random effect model for learning climate → autonomy satisfaction converged,

while the random effect models for the other two needs did not converge. For the learning climate → autonomy random effect model, the random term for this effect is significant (variance = 0.05, SE = 0.003, p < .001). There is a significant negative effect (standardized b = -0.11, SE = 0.02, p < .001) of individual-level autonomy satisfaction on the effect of learning climate on situational autonomy. In other words, the higher autonomy satisfaction that a student perceives across courses, the lower effect the student will receive from an autonomy-supportive learning climate specifically in that classroom. For competence, although the unconditional model did not converge, the conditional model in which the random effect is explained by individual-level competence converged. The moderating effect of individual-level competence on the learning climate → autonomy effect is also significantly negative (standardized b = -0.22, SE = 0.10, p < .001). Hence, overall, there is some evidence supporting the buffering effect, such that higher levels of general autonomy and competence satisfaction lowers the dependence of student on classroom-specific learning climate to derive respective needs satisfaction.
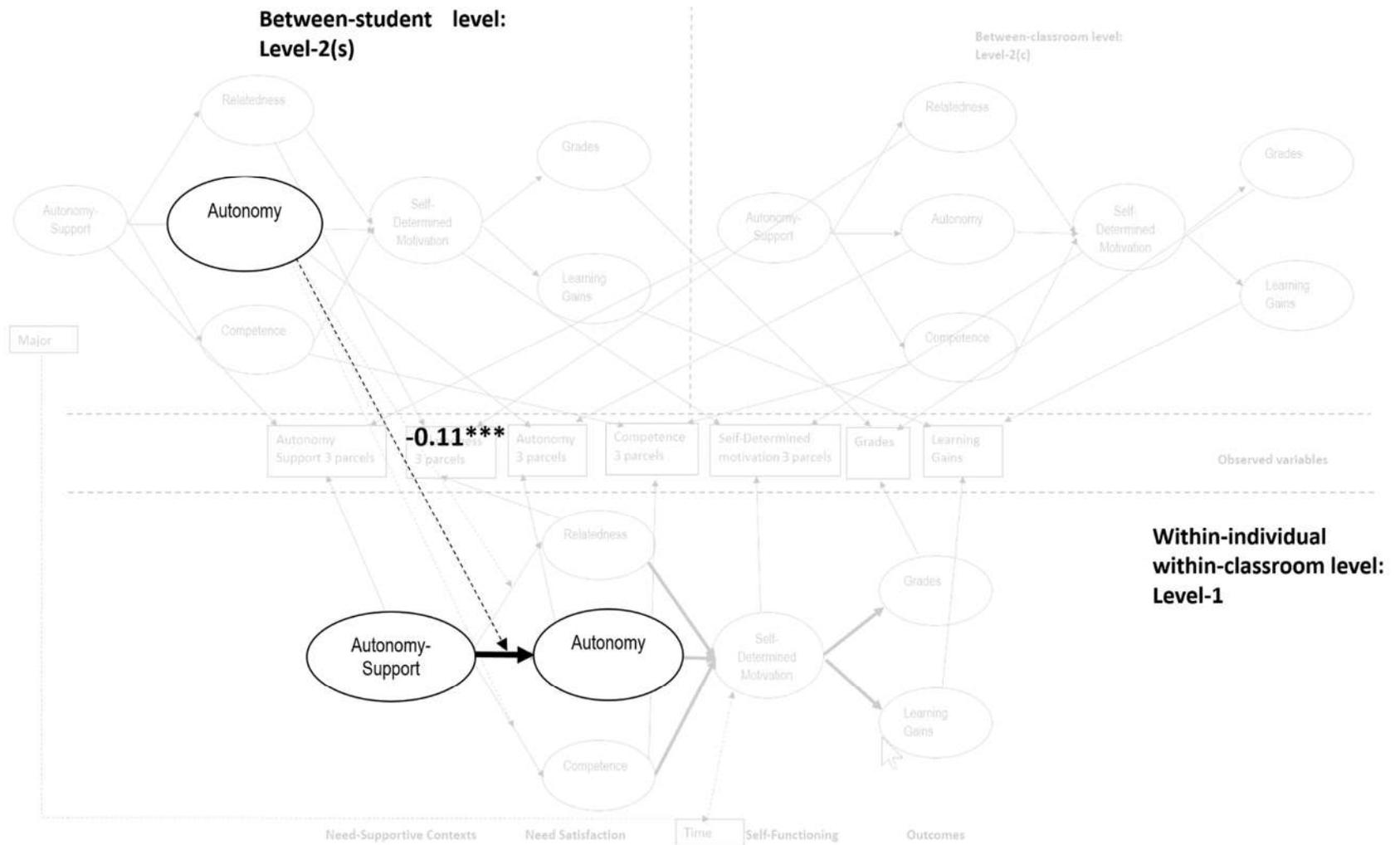
Figure 10: Moderation Effect of Individual-Level Autonomy

DISCUSSION & CONCLUSION

Main Research Question on the Within-Individual Level

The main findings of the current study answer the main research question: After controlling for student- and classroom-level variations, at the within level, classroom climate predicts college students' satisfaction of the needs for autonomy, relatedness, and competence, and autonomy and competence then predict self-determined motivation, which then predicts self-assessed learning gains. The current findings highlight the importance of the need support, need satisfaction (especially competence), and self-determined motivational processes in the college learning context, with a degree of methodological rigor (in terms of sample size, analytical details, etc.) unprecedented by previous literature.

Although this is mostly consistent with prediction, I also found several unexpected results. First, competence has a dominant effect on self-determined motivation (whereas the effect of autonomy is weak and the effect of relatedness is non-significant). This result is consistent with some previous findings (e.g., Levesque-Bristol et al., under review), which also found that in college education settings, competence was the dominant determinant of students' motivational functioning. Although previous research (e.g., Levesque-Bristol et al., under review) has suggested this possibility, the current research is the first one to demonstrate this dominant effect at the within-individual level. In other words, although previous research has pointed out that students' general competence need satisfaction is far more important than general autonomy and relatedness for them being generally self-determined toward their studies, the current research is the first to point out that the competence a student experiences in a given classroom is far more important than autonomy and relatedness experienced in that classroom for the student's motivation toward that specific course. Hence, it is much more convincing than previous research in terms of demonstrating the dominant role of competence in classroom learning situations.

However, the current findings are neither completely in line with previous findings in Levesque-Bristol et al. (2018). The explanation given in Levesque-Bristol et al. (under review) was that in college learning, autonomy and relatedness satisfaction "feed into" competence need faction, which directly impacts motivation. The reasoning in that paper was that autonomy and competence are the kind of "back-stage support" needed for a student to feel competent, but

competence is the only factor that directly impacts self-determined motivation. However, this position is not supported by the current research, because the alternative model does not really fit better than the original model, and neither is the dominant effect of competence "explained away" by incorporating the competence-mediation model. Therefore, the current data does not explicitly favor the alternative competence-mediation model.

Therefore, more importantly, regardless of the model specifications, the findings that autonomy and relatedness do not seem to matter in the classroom after competence is controlled for is quite unusual considered under the SDT framework. Admittedly, SDT research has indicated that some needs are more important in certain situations, but a finding of zero effect for relatedness on self-determined motivation in the classroom still seems to run directly counter to the classic research in OIT, which showed that relatedness is critical for the process of internalization, a process central to motivation in learning. Here I tentatively raise an explanation. That is, students' need satisfaction for autonomy and relatedness still matter, but maybe those satisfaction come from a different context or a different source from classroom. Research has suggested that people derive need satisfaction from multiple contexts (e.g., Milyavskaya et al., 2009; Milyavskaya & Koestner, 2011; van der Kaap-Deeder, Vansteenkiste, Soenens, & Mabbe, 2016). Therefore, some contexts may be outside the classroom, but still contribute to learning motivation. For example, a student is interested and ardently engaged in learning French, maybe because he has a French girlfriend; a student considers taking a calculus course as fun and personally important, maybe because they want to be a math professor which gives them freedom to pursue their interests. In these examples, the satisfaction of relatedness and autonomy respectively in other life contexts outside the classroom contributes to the self-determined motivation in the learning in the classroom.

Several previous studies have supported this general importance of needs satisfaction across contexts. For example, Milyavskaya et al. (2009) showed that the balance of needs satisfaction in adolescents' life contexts at home, school, with friends, and in part-time jobs contribute to higher school adjustment. Van der Kaap-Deeder et al. (2016) showed that the autonomy support and control that young children receive from each of the life context (including with parents, siblings, and teachers) uniquely contribute to their well-being. Legault, Green-Demers, and Pelletier (2006) showed that high school students' perceived relatedness support from parents and friends are as important as relatedness support from teachers in terms of their effect on reducing academic amotivation; they also showed that the influence of teachers is more

germane to competence support, whereas the effect of parents and friends are more germane to relatedness support. Guay, Ratelle, Larose, Vallerand, and Vitaro (2013) showed that high school students' perceptions of autonomy support from fathers has incremental contribution to academic achievement above and beyond the autonomy support perceived of mothers and teachers. Hagger and Chatzisarantis (2016) showed that autonomous motivation in the classroom predicts autonomous motivation outside the classroom. A more recent study (Yu et al., 2018) also provided a support for this idea by pointing out that college students' learning motivation and achievements are also determined by more general contexts outside the classroom (i.e., the autonomy college students perceive of their major or academic discipline).

In sum, this explanation of cross-context needs satisfaction may reconcile the finding that competence is the predominant need in the classroom and the SDT propositions regarding the importance of all three needs. In spite of the relevant research reviewed in the previous paragraph, research that focuses on the out-of-classroom needs satisfaction of college students and the effect on self-determined motivation in the classroom is still lacking. Future studies should examine needs satisfaction across contexts and examine their interactions in college students. It would also be interesting to examine a follow-up question, which is whether the interplay of need satisfaction between contexts differ between students of primary, secondary and post-secondary education. A prediction could be that post-secondary students have much more differentiated and substantial life contexts outside the classroom than primary and secondary school students, hence they may less rely on the classroom for satisfaction of autonomy and relatedness (which explains the dominance of competence in college classrooms that we have found in the current study); rather, primary and secondary school students may still rely on autonomy and relatedness needs satisfaction from the classroom, so autonomy and relatedness provided by the teaching and learning environment may have more important roles.

The dominant effect of competence need, though seemingly unexpected from SDT (because SDT tends to assign a unique importance for the need for autonomy; see Ryan & Deci, 2017, p. 250), is in well consistency with motivation literature in education in general. For example, competence is the only need that plays a central role in all the three contemporary motivational theories reviewed in Chapter 2: For expectancy-value theory, competence is very closely related to the construct of expectancy; for attribution theory, perceptions of whether one can competently bring about the desired outcomes also underlies the motivating effect of different

types of attribution (e.g., controllable vs. non-controllable, internal vs. external to the person); not to mention the achievement goal theory, which is based on the differentiations in the conceptualizations of competence (whether it is about improving oneself or about surpassing others, for example). Therefore, the current findings highlight and reassure competence as the most important theme in motivation in education. That said, it should be noted that the current SDT framework, which is guided by the underlying humanistic philosophy, still provides unique value in explaining the antecedents and consequences of competence that is not addressed by the other theories (e.g., autonomy-supportive learning climate and self-determined motivation).

Learning climate also has a significant direct effect on motivation and perceived learning gains, indicating that some of the effects of learning climate on motivation and learning outcomes are not explained by the three basic needs. This finding may be explained by recent research that tries to identify additional need factors contributing to motivation (e.g., González-Cutre, Sicilia, Sierra, Ferriz, & Hagger, 2016; Martela, Ryan, & Steger, 2018). For example, Gonzalez-Cutre et al. (2016) showed that there may be a fourth need beyond what has been suggested in SDT, namely, novelty. That is, human beings also need to experience something not previously experienced or deviates from everyday routine. A more recent study (Jeno, Vandvik, Eliassen, & Grytnes, 2018) also showed that this novelty factor may mediate the relationship between learning environment and autonomous motivation and learning outcomes. In addition, competence also predicts perceived learning gains, above and beyond the effect of self-determined motivation. This may be explained by the positive connection between actual competence and actual learning gains.

Interestingly, course grades are not significantly associated with any other variable in the level-1 model. In fact, this finding is not alone in the literature. Although SDT proposes that self-determined motivation contributes to learning engagement and outcomes (e.g., Guay & Vallerand, 1996; Bao & Lam, 2008), previous findings regarding grades have been mixed. Whereas some studies supported the positive effects on grades as predicted by the theory (e.g., Levesque-Bristol, et al., under review), there are quite a few studies that failed to find a relationship between self-determined motivation and course grades or GPA (e.g., Baker, 2004; Black & Deci, 2000; Chen & Jang, 2010; Conti, 2000; Svanum & Aigner, 2011). One possible explanation is that self-determined motivation is most closely predictive of learning activities that involve deep thinking, as opposed to rote learning, while course grades very often are a reflection of the latter. Indeed, one could easily imagine a student who grudges learning but still painstakingly put a lot of effort

into memorizing the textbook just to get a good score on the exam. Past SDT research has also supported this view, showing that self-determined motivation may not be associated with rote learning performance (e.g., Benware & Deci, 1984; Vansteenkiste et al., 2005). A second possibility is revealed in the multilevel findings in the current study. That is, although grades is not related to any variable on level-1 and on the between-individual level, it is significantly positively predicted by competence on the between-classroom level. In other words, classrooms where students are higher in competence need satisfaction also tend to have higher overall grades. Therefore, it is possible that although grades are not an effective student-level outcome, it may serve a good performance outcome on the course level.

General SDT Model on the Student- and Classroom-Levels

On the between-individual and between-classroom levels, these patterns are replicated: Learning climate significantly predicts all three needs; competence is the dominant predictor for motivation; self-determined motivation is a relatively strong predictor for perceived learning gains. We also observed that the strength of relationships at the between- levels are generally stronger than those on the within-level. This finding may find some consistency with a recent research (Fisher et al., 2018), which also found that the magnitude of the relationships between the same set of variables tend to be higher at the between-person level, compared to the within-person level. However, as Fisher et al., (2018) commented, they were the first to examine this issue, so there is not much reference that the existing literature could provide. The current study hence serves as a reference for future studies that examine the issue of ergodicity in educational settings. Although the exact meaning of this phenomenon is uncertain, here we tentatively provide a speculation: This result is reminiscent of the argument that some variables and/or psychological mechanisms are inherently more operant on certain levels. For example, Na et al. (2010) showed that constructs such as interdependent vs. independent social orientation and analytic vs. holistic cognitive style only show difference at the cultural level, but not at the individual level; as such, these variables inherently describe cultural, but not individual, phenomena. Similarly, in the current finding, it is possible that self-determination processes are inherently more about general individual need satisfaction, than about fluctuations in a specific classroom.

One unexpected finding on the between-classroom level is the suppression effects. Because of the high multicollinearity between variables, the loadings of some predictors become negative,

whereas others become larger than usual. This, again, highlights the importance of competence need satisfaction in college learning. In addition, the fact that the suppression effect is found only on the between-classroom level is consistent with the phenomenon discussed in the preceding paragraph, i.e., the multi-collinearity between independent variables may be especially strong in some higher levels. Overall, while results are reported for the higher levels, they are not the main results of the current study, and should be interpreted with caution, because there are additional nesting structures that are not controlled for these higher levels (e.g., major, instructor).

Supplemental Research Question 1: Temporal Change & Difference Between Majors

Supplemental Research Question 1 is also answered: The current study is the first to systematically document the temporal change in self-determined motivation and related perceptions of autonomy-supportive social climate in college students. While previous studies using primary and secondary school students have found mostly deteriorating trends, the current study found the average trend to be null. However, between-level moderation analysis showed that there is a significant difference between majors, such that students in business-related majors experience a decrease, and social sciences/humanity students experience an increase in self-determined motivation. This is an interesting finding in light of previous literature, in which the high consistency between the studies indicates that the motivational dynamics is highly homogeneous in younger children and adolescents, while our results showed that the relationship is far more heterogeneous for college students. Therefore, it seems to be a good description to say that primary and secondary students feel their learning activity as less and less interesting and/or personally important over the years, but for college students, it all depends on the person and the academic discipline they study in.

It is also interesting to compare the current findings with previous research conducted on college students. Although no research has examined the temporal change in self-determined motivation using a representative college sample, Sheldon, Arndt, and Houser-Marko (2003) found that college students tend to increasingly endorse intrinsic values (e.g., valuing intimate relationships, personal growth, and contribution to the community) as opposed to extrinsic values (e.g., valuing wealth, fame, and personal image), over the course of their studies. The endorsement of intrinsic vs. extrinsic values is closely related to self-determined motivation (Sheldon, Ryan, Deci, & Kasser, 2004), so they concluded that their findings demonstrated the inherent human

tendency to become self-determined and to do whatever is best for their organismic growth (also see Sheldon, Houser-Marko, & Kasser, 2006). Ironically, in light of the current research, the validity of their claim seems to be overturned, because in all their three sub-studies they have used psychology students. Had they known that the major is critical in the dynamics of self-determination, they wouldn't jump to the generalization to innate human propensity so quickly.

In fact, in later research conducted by Sheldon and colleagues (e.g., Sheldon & Krieger, 2004; Sheldon & Krieger, 2007), they have documented the phenomenon that for some majors, there may not be a general tendency toward higher self-determination. They showed that law school students' intrinsic motivation and well-being plummeted over the course of their program. The current study extends this line of differential thinking and depicts a more comprehensive picture. The current study contributes by pointing out business-related major as potentially deleterious, and social sciences and humanities potentially conducive, to students' motivation functioning over time. These findings serve as a powerful follow-up to the findings in Yu and Levesque-Bristol (2018), in which they found that students in business-related majors have on average lower levels of self-determined motivation, which is explained by their lower levels of perceived autonomy-supportive learning climate. Whereas Yu and Levesque-Bristol tentatively proposed that the learning climates in the majors are what causes differential levels of self-determined motivation, it was essentially a cross-sectional investigation, which depicts the difference at a static time-slice. In contrast, the current finding longitudinally demonstrates the dynamic deterioration vs. improvement of motivation and learning climate over time. As such, it is a piece of far more convincing evidence for the ongoing conducive vs. harmful influence exerted by certain academic disciplines.

Another interesting minor finding is that when using time and dosage to predict learning climates, time showed a positive effect whereas dosage showed a negative effect. The negative dosage effect means that the more IMPACT courses students take, the lower autonomy support they are likely to perceive of their classrooms. This is apparently contradictory to the expectation that IMPACT courses improve autonomy support. One possible explanation is that students who have participated in multiple IMPACT courses may have habituated and have higher expectations for the level of autonomy support, and thus given a specific classroom they are less likely to think highly of it as autonomy-supportive.

Overall, one lesson learned from the current results is that it may be more fruitful to investigate the differences in change trajectories in self-determined motivation, rather than simply looking at the general tendency, especially in college setting. Future studies could employ analytical frameworks that are more specialized for this purpose, such as latent growth mixture modeling, to examine this issue of differential development (e.g., Ratelle, Guay, Larose, & Senecal, 2004). Similarly, in terms of practical implication, we suggest that whereas it may be more effective to improve primary and secondary school students' motivation using interventions at the level of curriculum or the educational system (because of the more homogeneous nature of their motivation dynamics), for college students, motivational interventions may be most effective targeting certain individuals or academic disciplines.

Supplemental Research Question 2: Moderation of Individual-Level Need Satisfaction

In the current research we also answered to the call of previous studies (e.g., Bartholomew et al., 2017) to examine between-student factors that affect students' sensitivity or resiliency to learning environments. The second supplemental research question, which regards the moderation effects of individual-level needs satisfaction, is less clearly answered though, because the model did not completely converge for all three needs. Nevertheless, there is some evidence for the habituation/buffering effect, such that the higher autonomy and competence needs satisfaction students generally get, the less their needs satisfaction in a specific classroom depends on the learning climate. The result is especially noticeable for autonomy, as it is the only model that completely converged. To illustrate, a student who always feel they have no choice and they are pressured to do school work (i.e., low on autonomy satisfaction on the individual-level) will be especially likely to feel they "own" their learning given a highly autonomy-supportive classroom (i.e., deriving positive autonomy satisfaction from a highly autonomy-supportive environment), and they are also especially likely to feel they are being pressured in their learning given a classroom low on autonomy support (i.e., deriving exceptionally lower autonomy satisfaction from a low-autonomy-supportive environment). This result is consistent with those obtained by Black and Deci (2000), Hagger and Chatzisarantis (2011), Levesque-Bristol et al. (under review), and Tsai et al. (2008), but inconsistent with others (e.g., Mouratidis et al., 2011; Reis et al., 2000).

This result is also consistent with recent research that showed a moderating role of *desire* for autonomy on the effect of autonomy need satisfaction (van Assche, van der Kaap-Deeder,

Audenaert, Schryver, & Vansteenkiste, 2018). The desire for autonomy is conceptualized as a deficiency-based motive to obtain more autonomy satisfaction. Van Assche et al. (2018) showed that the more one desires autonomy, the more their well-being depends on satisfaction vs. frustration of the need for autonomy. As such, desire may serve as a psychological mechanism that further explains the moderating effect found in the current research. That is, students who are chronically low on autonomy need may feel a desire toward experiencing higher levels of autonomy, which is then related to their higher responsiveness to autonomy satisfaction and frustration they experience. In a similar vein, future studies may also examine other individual differences related to general autonomy satisfaction that may impact need satisfaction processes at the within-individual level. For example, recent research has started to emphasize the resources within a student that may explain their active seeking for and obtaining of needs satisfaction (e.g., the concept of agentic engagement by Reeve, 2013; the concept of assertive autonomy by Legault, Ray, Hudgins, Pelosi, & Shannon, 2017). Future studies could examine the potential moderating effects of these more active components of autonomy in individual differences.

In general, our findings suggested that although the need for autonomy is not a salient predictor on the within level, it does have a moderating role on the between-individual level. These results also suggest that students who chronically experience lower levels of autonomy and competence are especially at risk for less need-supportive classrooms. Therefore, more attention should be paid to these students in intervention. This converges with our suggestion in previous paragraphs that it would be most effective for intervention at the college level to focus on students who are lower on satisfaction in general.

Other Considerations

To our knowledge, the current study is one of the first to apply a cross-classified multilevel SEM framework to educational research; it is also the first to apply cross-classified multilevel SEM to examine SDT propositions. The current research provides some implications for using this method. First, the current research demonstrated the feasibility of using the cross-classified SEM method to simultaneously control for individual student-level and classroom-level variations and estimate relatively complex models. However, this feasibility seems to be limited to path models only. The difficulties in the current study to fit models that have latent variables on the within-individual level has suggested that the observed indicators may not factor into the same latent

constructs the same way on different nesting levels. Second, the models on different levels showed substantial similarity, although it is uncertain whether this is limited to the characteristics of only the current dataset. Third, one limitation suggested by the current findings is that, on some levels the correlations between constructs may be so high that the multicollinearity will cause suppressor effects to happen. This provides a caution for future studies that aim to apply this method.

The current study has several limitations. First, the data is collected from courses that underwent a transformation project in one Midwest US university, and it is unknown how much impact this has on the generalizability of the findings to all courses in all universities. According to my literature review, very little research has examined the potential differences between courses that participate in an intervention program to improve student-centeredness vs. regular classrooms. The only research that systematically examined this issue is a meta-analysis (Su & Reeve, 2011), showing that interventions that aimed to improve autonomy support were generally effective on a moderately large degree ($d = 0.63$). Therefore, it is possible that the current research context (the IMPACT program) is a space with rather rich autonomy support. The implications of such an augmented space is that the variables and the relationships between them may be examined under range restriction. For example, a previous study (Yu, Traynor, & Levesque-Bristol, 2018) showed that the latent level of learning climate in the current sample is so high that it falls outside the higher extreme of the LCQ measurements. In a similar vein, the augmented space may also in some way alter the relationships between variables. For example, the findings of the dominant effect of competence is highly unique in the current sample compared to previously published studies, and I am not sure if it has to do with the intervention nature of the sample. Notwithstanding, it should be noted that these limitations should be minimal, because otherwise we would see a large difference between students who participated in a large number of IMPACT courses vs. those who only participated once in IMPACT courses. This is not the case, as is demonstrated in Table 1 and in the Data section. Future studies may run this model in non-IMPACT courses and compare with the current findings.

Second, although the model intended to incorporate all variables typically examined in SDT, there are a few variables of important conceptual interest that are not included, such as well-being and vitality. Especially, course grades as a learning outcome did not function well in the current analyses; future studies should incorporate other types of learning outcome, such as behavioral engagement, using real learning assignments. Likewise, we found competence to be the

most important need in college classrooms, but the current model does not examine classroom environments that are supposed to specifically contribute to competence (such as providing structure). Future studies should also incorporate measurements of classroom support that are directly related to competence. Third, relatedly, the learning climate is measured with student self-report. Future studies should use more objective or multi-informant measures to reduce common method bias. Fourth, the model itself could not differentiate temporal precedence between variables, and longitudinal models more specialized to test temporal precedence should be employed in the future. Fifth, the model emphasizes the relationships between need support, need satisfaction, motivation, and normative or positive learning outcomes, whereas recent research has started to differentiate the negative side of the model, in which need-thwarting environments have a unique contribution to needs frustration, which then contributes to non-self-determined motivation and negative outcomes (e.g., Cheon et al., 2018). Future studies could aim to differentiate these different sides of the model.

Take-Home Messages

The current study supports various propositions in the General SDT Model at the within-individual within-classroom level. I found that a given student's perception of classroom to be autonomy-supportive predicts that student's higher level of autonomy, relatedness, and competence within that classroom; autonomy and competence then predicts higher levels of self-determined motivation, which explains higher levels of self-reported learning gains. I also found that the effect of competence is dominant among the three needs, thus highlighting the importance of dominance in college learning experiences.

When I look at students' motivation across years in their college studies, I found a flat trajectory. However, there is substantial variation between students, and that variation is explained by the majors that the student studies in. Students in business-related majors tend to decrease, whereas students in social sciences/humanity majors tend to increase, in their self-determined motivation and perceptions of autonomy-supportive learning climate.

Some evidence is found for a habituation/buffering effect of autonomy and competence need satisfaction, such that students who are generally higher on the satisfaction of these needs tend to be less affected by the environment of a particular classroom.

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APPENDIX

Note: All scales below share the same scale:

Scale points:

1 - Strongly Disagree

2 - Disagree

3 - Somewhat Disagree

4 - Neither Agree Nor Disagree

5 - Somewhat Agree

6 - Agree

7 - Strongly Agree

LEARNING CLIMATE QUESTIONNAIRE (SHORT-FORM)

The questions below are related to your learning experience in [fill in course name] 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 [fill in course name]. Your responses are confidential. Please be honest and candid. Use the scale provided below to answer each item.

I feel that my instructor provides me choices and options.

I feel understood by my instructor.

My instructor conveyed confidence in my ability to do well in the course.

My instructor encouraged me to ask questions.

My instructor listens to how I would like to do things.

My instructor tries to understand how I see things before suggesting a new way to do things.

ACADEMIC MOTIVATION SCALE

Motivation for taking [fill in course name]

The questions below are related to your feelings of why you are taking [fill in course name]. Students have different motivations for taking different courses, and we are interested in your motivations for taking [fill in course name] thus far. Your responses are confidential. Please be honest and candid. Use the scale provided below to answer each item.

1. Because it allows me to develop skills that are important to me.
2. Because I would feel bad if I didn't.
3. Because learning all I can about academic work is really essential for me.
4. I don't know. I have the impression I'm wasting my time.
5. Because acquiring all kinds of knowledge is fundamental for me.
6. Because I feel I have to.
7. I'm not sure anymore. I think that maybe I should quit (drop the class).
8. Because I really enjoy it.
9. Because it's a sensible way to get a meaningful experience.
10. Because I would feel guilty if I didn't.
11. Because it's a practical way to acquire new knowledge.
12. Because I really like it.
13. Because experiencing new things is a part of who I am.
14. Because that's what I'm supposed to do.
15. I don't know. I wonder if I should continue.
16. Because I would feel awful about myself if I didn't.
17. Because it's really fun.
18. Because that's what I was told to do.

Intrinsic motivation: 8, 12, 17
Integrated extrinsic motivation: 3, 5, 13

Identified extrinsic motivation: 1, 9, 11

Introjected extrinsic motivation: 2, 10, 16

External extrinsic motivation: 6, 14, 18

Amotivation: 4, 7, 15

BASIC PSYCHOLOGICAL NEEDS SCALE

Your Overall Experience

The following questions concern your feelings about your experience in [fill in course name]. Please indicate how true each of the following statement is for you given your specific experiences with [fill in course name] thus far.

1. I feel like I can make a lot of inputs in deciding how my coursework gets done.

2. I really like the people in this course.

3. I do not feel very competent in this course.

4. People in this course tell me I am good at what I do.

5. I feel pressured in this course.

6. I get along with people in this course.

7. I pretty much keep to myself when in this course.

8. I am free to express my ideas and opinions in this course.

9. I consider the people in this course to be my friends.

10. I have been able to learn interesting new skills in this course.

11. When I am in this course, I have to do what I am told.

12. Most days I feel a sense of accomplishment from this course.

13. My feelings are taken into consideration in this course.

14. In this course I do not get much of a chance to show how capable I am.

15. People in this course care about me.

16. There are not many people in this course that I am close to.

17. I feel like I can pretty much be myself in this course.

18. The people in this course do not seem to like me much.

19. I often do not feel very capable in this course.

20. There is not much opportunity for me to decide for myself how to go about my coursework.

21. People in this course are pretty friendly towards me.

Autonomy: 1, 5(R), 8, 11(R), 13, 17, 20(R),

Competence: 3(R), 4, 10, 12, 14, 19,

Relatedness: 2, 6, 7(R), 9, 15, 16(R), 18(R), 21