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Investigating the Relationship among Faculty Knowledge of Self Determination Theory, the Classroom Learning Environment, and Engineering Student Outcomes

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Abstract

The relationship between the faculty knowledge of *Self-Determination Theory* (SDT; Deci & Ryan, 1985) and the actual classroom environment has not been researched in engineering disciplines in terms of student outcomes. While research supports the relationship between motivation and student learning, little empirical research has focused on the combined components of SDT (autonomy, competence and relatedness), faculty knowledge of SDT, its translation into undergraduate engineering instruction, and the impact on student learning.

The research design and measurement framework are developed through collaboration among the researchers from Engineering, Psychology, and Education. This project also takes advantage of current standards and techniques employed in the field of Social-Cognitive Psychology. From a broad perspective, this field provides a framework to guide and support how individuals (faculty and students) perceive, interpret and remember their interactions with each other. This paper overviews the initial faculty perceptions of autonomy and aspects of the SDT faculty workshop. Additionally, it presents analyses from three waves of student surveys from over 250 undergraduates that were conducted in Fall 2013 through Fall 2014. Forty-three (64%) engineering faculty participated across the same period of time. Analyses highlight the relationship between faculty knowledge and student perception of the classroom learning environment as they relate to student learning outcomes.

Introduction

Improving engineering education is a challenging and persistent national issue that has implications for the number and quality of future U.S. engineering and technological workforce. Indeed, there is a significant amount of research that attempts to identify what specific aspects of engineering education can be improved and strategies for reaching those goals. For example, the traditional "development and dissemination" approach to teaching has been identified as a major barrier to the STEM reform efforts [1]. Concurrently, research from the field of Social-Cognitive Psychology has investigated the role of student motivation and its impact on academic achievement [2,3,4,5,6,7,8].

One theory from Psychology, Self-Determination Theory [9], states that there are three innate psychological needs—autonomy, competence, and relatedness—which when satisfied can promote intrinsic motivation and increase student learning outcomes. In this model, *autonomy* can be conceptualized as having choices that are self-endorsed instead of driven by external control. *Competence* refers to having a desire to master certain skills, and can promote intrinsic motivation when accompanied by a sense of autonomy. Competence is also the belief in one's self-efficacy to meet the challenges that they face. Lastly, *relatedness* can be construed as a sense of purpose of pursuing certain actions or being connected to others in a social framework. Higher intrinsic motivation has been linked to increased student academic performance as measured by a variety of outcomes, including standardized test scores and subjective ratings by teachers [6,7,8,10,11,12,13].

Faculty undoubtedly play a critical role in the classroom and beyond in improving motivation and the student learning experience [14]. More specifically, through their teaching practices in the classroom, faculty can help students meet (or not) their three innate psychological needs (*autonomy*, *competence* and *relatedness*) and thus promote (or hinder) students' intrinsic motivation for learning. To date, no research has (a) investigated what Engineering faculty know about Self-Determination Theory and it's relationship to student learning, (b) explored whether faculty awareness and knowledge of *Self-Determination Theory* (SDT) [6] has any beneficial impact on classroom learning environment and student learning, and (c) investigated whether student-level factors, such as the perception of the Engineering classroom environment, also contributes to student learning outcomes.

Research Questions and Hypothesis

In the current research, instructors and students in the various Engineering Departments at Florida Atlantic University (FAU) served as the participants. The research design and measurement framework were developed through collaboration between the researchers from Psychology, Education, and Engineering. This takes advantage of current standards and techniques employed in the field of Social-Cognitive Psychology.

The current research was designed to address the following two research questions:

1) What do faculty know about Self-Determination Theory and its association with student learning outcomes?;
2) What is the relationship between faculty knowledge of SDT, student perception of the classroom environment, and student learning outcomes?

Preliminary research conducted at Florida Atlantic University found that increased student perception of autonomy in the classroom was related to favorable student outcomes such as increased grades and perceived amount of learning. Based on these results, we expect to replicate these findings across three waves of data beginning in the Fall of 2013 through the Fall of 2014. Based on the preliminary findings, we propose the following hypothesis:

Hypothesis: Students in classes with faculty that endorse autonomy (versus controlled) as sources for student motivation will earn better grades and report more learning.

Method

In order to investigate our research objectives and hypothesis, we employed a number of measures designed specifically for this study. We assessed faculty knowledge about *Self-Determination Theory*, and students' perception of the classroom environment. Lastly, objective (academic performance outcomes, i.e., grades) and subjective measures (perceived amount of learning) comprised our student learning outcomes.

Faculty Knowledge of Self-Determination Theory Questionnaire. To measure what the faculty know about *Self-Determination Theory* and its association with student learning, we adapted a measure tapping students' motivation to be from the faculty point of view. Faculty rated the degree to which they thought twelve student motives for learning either inhibit or promote learning. The twelve items were rated on a 5-point scale ranging from 0 (*strongly inhibits learning)* to 4 (*strongly promotes learning*). The questionnaire contains two subscales that measure faculty knowledge of Autonomous regulation (Cronbach's alpha = .81) and Controlled regulation (Cronbach's alpha = .88). Lower scores on the Controlled regulation subscale combined with higher scores on the Autonomous regulation subscale are indicative of more faculty knowledge of Self-Determination Theory. The full questionnaire is available in the Appendix.

Learning Climate Questionnaire. To measure students' perception of the classroom environment, we used the Learning Climate Questionnaire (LCQ) [15,16,17,18]. The LCQ consists of 15 items rated on a 7-point Likert type scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). When composited, measures (according to students) how autonomy supportive the classroom environment is (example item: "I feel my instructor provides me choices and options"). The LCQ is a well-validated measure that has been used in a number of studies examining university classrooms and learning outcomes.

Student Learning Outcomes. We measured student learning outcomes in two distinct ways. First, student learning outcomes were measured subjectively with one question adapted from FAU's Student Perception of Teaching (SPOT) evaluations. The SPOT evaluations are administered to all students in the final weeks of each semester for each course and consist of 21 questions about the course, the instructor, and how much students have learned. As a subjective measure of student learning outcomes, the item, "How much do you think you have learned in this course?" was rated from 1 (*an exceptional amount*) to 5 (*almost none*). Second, student learning outcomes is measured objectively via final grades in the course. We obtained these final grades from the university registrar. Using these related, but non-overlapping, measures of learning outcomes allows us to understand and explore the impact of SDT may have on different kinds of learning.

A summary of these aforementioned measures, along with a brief description, their purpose, and the assessment strategy for each is provided below in Table 1.

Table 1: Measures Employed in the Research

Measure	Description	Purpose	Assessment(s)
Faculty Knowledge of SDT Questionnaire	12 items adapted from William & Deci [16]	Faculty Knowledge of Self-Determination Theory	From faculty beginning of Fall 2013
Learning Climate Questionnaire (LCQ)	15 items from William & Deci [16] rated on a 1-7 scale	Measure classroom learning environments	From students mid-semester in Fall 2013 through and Fall 2014
Self-reported Learning (from SPOT)	"How much do you think you have learned in this course?" rated from 1-5	One measure of student learning outcomes	From students at the end of semester in Fall 2013 through and Fall 2014
Student Grades	Grades for each course assessed on a 4.0 scale	A second measure of student learning outcomes	From university registrar at the end of Fall 2013 through and Fall 2014

Procedure

Faculty survey. In the Fall of 2013, we sent all faculty in the College of Engineering/Computer Science our Faculty Knowledge of SDT questionnaire. Nearly two-thirds (64%) of the faculty completed the questionnaire.

Student surveys. About halfway through the Fall 2013 semester, we sent students a survey regarding their perceptions of the classroom environment (the LCQ; see Measures above). After each semester, we sent students a second survey with the single item question regarding how much they learned in their classes. Lastly, we obtained students' final grades from the university registrar. This procedure was repeated in the Fall 2013, Spring 2013, and Fall 2014 semesters.

Analytic Strategy

To avoid potential statistical complications caused by measuring the same participants (both faculty and students) at different time points (i.e., non-independence), Multi-level Modeling (MLM; also referred to as Hierarchical Linear Modeling {HLM}) was employed [19,20]. At each measurement time point, students and faculty provided us with their FAU issued identification numbers. These numbers served as a unique identifier for each participant for each measurement period.

To test the hypothesis that students in classes with faculty that endorse autonomy (versus controlled) as sources for student motivation will earn better grades and report more learning two analyses were conducted using MLM. To reiterate, MLM is necessary because of the nonindependence introduced by students and faculty being nested in classrooms, and because this study employs repeated measures. The general MLM, following Raudenbush & Bryk [19], equations for these analyses are listed below:

Level 1: $Y_{Learning} = \beta_0 + \beta_1 X + r$

Level 2: $\beta_0 = \gamma_{00} + \gamma_{01}\omega + U_0$

$\beta_1 = \gamma_{10} + \gamma_{11}\omega + U_1$

Mixed Model: $Y_{Learning} = \gamma_{00} + \gamma_{01}\omega + \gamma_{10}x + \gamma_{11}\omega x + U_1 x + U_0 + r$

As these equations indicate, a Level-1 (L1) linear regression was used to predict learning outcomes ($Y_{learning}$: e.g., students' responses to the item, "How much do you think you have learned in this course?") from student-level (L1) predictors (X). Such L1 predictors will include reports of the classroom environment (LCQ). The intercepts and slopes for each classroom will then serve as outcomes in a regression at Level-2 (L2) and classroom-level predictors (ω) such as Faculty knowledge of Self-Determination Theory will be used to predict differences in classroom intercepts and slopes. While it is instructive to consider this analysis as two separate sets of linear regressions, in practice all regression coefficients (i.e., the Mixed Model) are estimated simultaneously using maximum likelihood estimation with empirical Bayesian estimation of slopes [19,20]. The major advantage of this approach is that it appropriately estimates the relationships between the key variables (i.e., learning outcomes and classroom environment) while taking directly into account the fact that, students are nested within classrooms.

Results

Research Question 1 – To address our first question –what do the faculty know about Self-Determination Theory and its association with student learning outcomes—we created composites of the Autonomous and Controlled subscales of the questionnaire. The results of the faculty questionnaire are presented in Table 2.

Table 2: Descriptive statistics for Faculty Knowledge of Self-Determination Theory Questionnaire.

Subscale	Mean	*SD*	Alpha
Autonomous	3.36	.60	.81
Controlled	2.71	.65	.88

Note. n = 43.

On average, faculty reported that they thought students relied on both autonomous and controlled sources of motivation. Indeed, these two subscales were moderately correlated, r =. 34 (see Figure 1).

Research Question 2 – To address our second research question—what is the relationship among faculty knowledge of SDT, student perception of the classroom environment, and student learning outcomes—we estimated two multilevel models. In the first model, we predicted grade points (e.g., A = 4.0, A- = 3.70, etc.) in students' classes from faculty scores on the Faculty Knowledge of Self-Determination Theory questionnaire, and students' perception of autonomy support in the classroom learning environment using scores from the Learning Climate Questionnaire (LCQ). In the second model, we predicted students' self-reported learning (e.g., "How much do you think you have learned in this course?") from scores on the Faculty Knowledge of Self-Determination Theory questionnaire, and students' perception of autonomy support in the classroom learning environment.

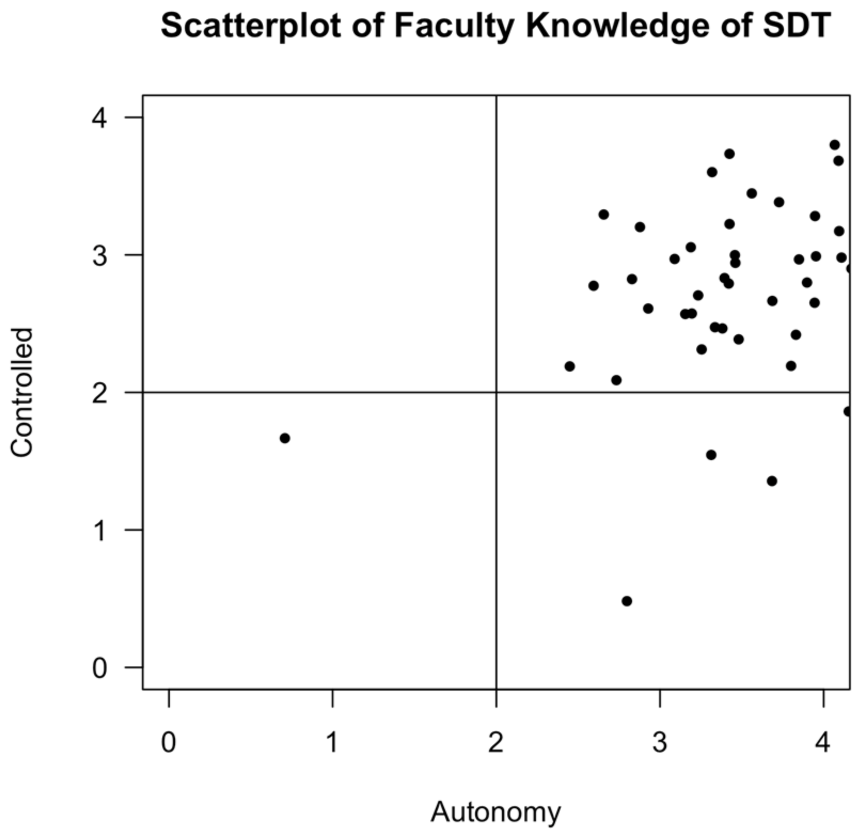

Figure 1: Scatterplot of faculty beliefs about the relative importance of controlled versus autonomous learning environments.

Note. N = 43. Faculty tended to think students relied on both autonomy and controlled sources of motivation, although this relationship was only moderate (r = .34).

In an effort to reduce the number of predictors at Level 2, we calculated a relative Autonomy score for faculty by subtracting Controlled subscale scores on the Faculty Knowledge of SDT questionnaire from scores on the Autonomous subscale. For the purposes of the current paper, we refer to relative Autonomy and Faculty Knowledge of SDT interchangeably. Next, scores on the Faculty Knowledge of Self-Determination Theory questionnaire were grand mean centered and entered at Level 2. Students' mean perception of autonomy support in the classroom learning environment were entered at Level 2. Lastly, students' perception of autonomy support was within-person centered at Level 1. The effects of students' perception of autonomy support in the classroom environment (within-person centered) were estimated as random effects. All predictor variables were entered simultaneously.

The fixed effects of the model are presented in the upper half of Table 3. For example, the slope of .36 indicates that for every 1-point increase in scores on Faculty Knowledge of SDT, students earned higher grades (nearly half of a letter grade). Thus, practically speaking, students tended to earn higher grades when attending classes with faculty that believe autonomy promotes learning. Similarly, a 1-point increase in students' average perceived autonomy support is associated with a .12 increase in students' grades. Therefore, students' perception of the autonomy they receive in the classroom also predicts final grades earned in the course. To illustrate this relationship, we first aggregated students' grades across all classes taught by each faculty member. Next, we correlated these means with the relative Autonomy scores for each faculty member (see Figure 2.)

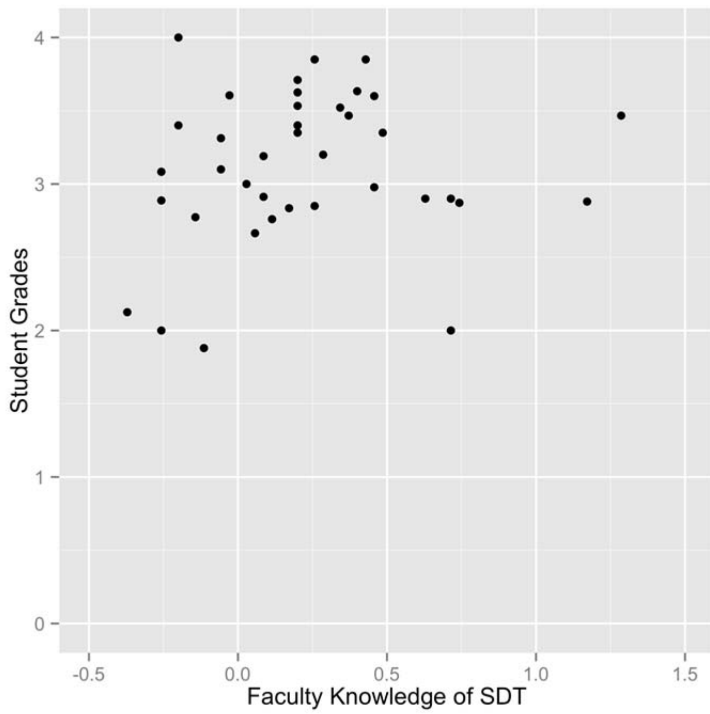

Figure 2: Scatterplot of Faculty Knowledge of SDT and student grades

Table 3: Fixed Effects of Multilevel Models.

Student Learning Outcome	*b*	LL	UL	*t*
Grade Earned in Course	2.43	1.88	3.01	
Faculty Knowledge of SDT	.36	-.03	.76	1.74
Autonomy support	.07	-.13	.31	0.71
Mean Autonomy support	.12	.02	.22	2.47
Self-Reported Learning	0.60	-1.69	2.50	
Faculty Knowledge of SDT	-.71	-1.77	.43	-1.43
Autonomy support	-.16	-.79	.57	-0.58
Mean Autonomy support	.48	.15	.89	2.89

Note. Grades analyses based on 38 faculty and 282 student reports. Learning analyses based on 21 faculty and 43 student reports. *b*s are unstandardized multilevel regression coefficients. LL and UL represent lower and upper limits for 95% confidence intervals respectively based on *K* = 500 bootstrap resamples.

To investigate the relationship between the subjective learning outcome (i.e., how much students felt they learned in the course) and Faculty knowledge of SDT, we conducted the same analysis from the first model but instead substituted the SPOT score as the dependent variable. The fixed effects of this model are presented in the lower half of Table 3. The results demonstrate that for every 1-point increase in scores on Faculty Knowledge of SDT, students reported learning less in the course. However, students' perception of Autonomy was related to increased subjective learning. These results should be considered preliminary in light of the number of faculty and student reports.

Discussion

The present research is the first of its kind to investigate what Engineering faculty know about Self-Determination Theory and its association with student learning outcomes. As the results demonstrate, faculty do appear to know at least at an implicit level, the role of autonomy in increasing students' intrinsic motivation. Indeed, students in classes with faculty who believe autonomy (versus external, controlling factors) is critical to motivation, tended to earn higher grades. We also considered whether students' perception of autonomy in the classroom was also related to final course grades and student learning. Although data collection is still ongoing, the tentative answer to this question appears to be yes. Our future research will focus on recruiting both students and new faculty to participate in subsequent semesters.

Conclusions

- Faculty tended to believe that students rely on both autonomous and controlled sources of motivation to learn.
- Faculty who believe autonomy is a critical factor in student motivation tended to have students that earned higher grades.
- Data collection is ongoing to fully investigate the relationship among Faculty Knowledge of SDT, the classroom learning environment, and students' objective and subjective learning outcomes.

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Appendix

Knowledge of *Self-Determination Theory* Measure: We asked engineering students what motivates them to learn in their engineering classes. The list below contains 12 of the most common responses. Please indicate the degree to which you as a faculty member think each of these student motives for learning inhibits or promotes learning (Table 1).

Table 1: Faculty Perspective

Strongly Inhibits Learning	*Somewhat Inhibits Learning*	*Neither Inhibits nor Promotes Learning*	*Somewhat Promotes Learning*	*Strongly Promotes Learning*
0	1	2	3	4

1. "Because my parents will be proud of me."
2. "To understand more about the nature of engineering."
3. "Because I will be embarrassed if I get a bad grade."
4. "To learn how to solve engineering problems."
5. "Because I will be proud of myself if I get a good grade."
6. "So that I will get good grades."
7. "So that my professor will think I am smart."
8. "Because a good grade in engineering will look positively on my record."
9. "So that my classmates will think I am smart."
10. "Because I am personally interested in the subject."
11. "Because it's a challenge to understand how to solve engineering problems."
12. "To get a college degree."

Items 2, 4, 10, and 11 can be combined to obtain an "Autonomous Regulation" component, while items 1, 3, 5, 6, 7, 8, 9, and 12 can be combined to form a "Controlled Regulation" component. Given the research demonstrating that autonomous regulation is better associated with learning outcomes [31,32], we will consider higher scores on Autonomous Regulation and lower scores on Controlled Regulation to indicate better Faculty knowledge of *Self-Determination Theory*.