# Exploring the disconnect between Self Determination Theory (SDT) and the Engineering Classroom Environment

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## Abstract

This paper is part of NSF Grantees' Poster Session at the ASEE 2014 Annual Conference, and describes a recently funded project (October 2013) under the *Research Initiation Grant in Engineering Education* (RIGEE) program. It is hypothesized that there is disconnect between the principles outlined in *Self-Determination Theory* (SDT) and the actual classroom environment, thus creating a barrier to intrinsic motivation needed for student learning. The proposed work is an empirical investigation to explore this disconnect in the context of undergraduate engineering education. The primary tasks will be to (i) assess the Faculty knowledge of SDT; (ii) develop a measurement framework to assess the classroom environment as it relates to SDT; and (iii) determine the association among Faculty knowledge of SDT, student motivation, learning environment, and student learning. The research design and measurement framework are developed through a meaningful collaboration between the researchers from Engineering, Psychology, and Education. This takes advantage of current standards and techniques employed in the field of Social-Cognitive Psychology. Since the beginning of this project in Fall 2013, a total of 104 undergraduate students and 50 engineering Faculty at Florida Atlantic University participated in the study, and the preliminary findings will be presented in this conference.


## Introduction

Improving engineering education is a challenging and persistent national issue which can significantly impact the number and quality of future U.S. engineering and technological workforce. According to the budget data published by the National Science Foundation, the Directorate of Education and Human Resources alone has funded in excess of $28 billion toward reforming STEM education during the 60-year span from 1951 to 2011 [8]. This sustained effort led to the development and dissemination of several research-based pedagogies which advocate that transforming the instructional method from a traditional unidirectional transmission style (passive mode) to a more interactive student-centered style (facilitative mode) is linked to improved learning [1-5]. However, these reform efforts continue to have only marginal impact on engineering instruction because there has not been any wide scale acceptance and/or adoption of these pedagogical models by the Faculty in their classroom environment [1]. In fact, the traditional "development and dissemination" model has been identified as a major barrier to the STEM reform efforts [1]. Student-centered learning approaches are quite suitable in certain classrooms with certain characteristics, but they do not work well in all classrooms. This is because such prescriptive approaches often offer "one-size fits all" solutions to improving student learning, thus restricting the *autonomy* of Faculty.

## Motivation for the Study

The motivation for this research originated from long-standing (and continuing) discussion among the engineering investigators focusing on their own personal experience and observations,

all related to growing concerns about student motivation and learning. These are summarized below:

(a) Even though there exists rich empirical evidence about the success of student-centered approaches (e.g. project-based, inquiry-based, active learning, etc.) in improving student motivation and learning [1-5], most engineering instructors at FAU continue to follow traditional method of unidirectional lecture-based instructions.

(b) In an effort to improve teaching and learning, Florida Atlantic University has sponsored more than twenty five Faculty Learning Communities (FLC) since 2008 [12], with broad participation by the engineering Faculty. Some of these FLCs incorporated topics such as *Inquiry-based Learning*, *Active Learning*, *Project-based Learning*, *Problem-based Learning*, *Critical Thinking*, *Academic Service Learning*, etc., in which the faculty participants were encouraged to explore and implement a student-centered alternative teaching approach for two semesters and document any difference in student motivation and learning. However, informal conversations between the researchers and their engineering colleagues reveal that, except for few instances, most of the FLC participants went back to their usual routines of traditional instructional methods. It clearly supports the conclusions made by Dancy and Henderson [1] that the "development and dissemination" model with "prescriptive" approaches are not working, even though Faculty are fully knowledgeable about the effectiveness of such approaches.

Through ongoing discussions and brain-storming, the research team realized that the issue of Faculty *autonomy* and classroom *situational factors* may be critical in the way Faculty make important choices and decisions, which ultimately impact student learning. Also, the student-centered pedagogical techniques focus mostly on the student, and somewhat overlook the needs of the Faculty and the pivotal role they play in the whole process of educational reforms that involves Faculty, student, and the classroom environment. Therefore, the Faculty must be brought in "as part of the solution" to the growing problems surrounding engineering education. These discussions led to the realizations that there may be a "disconnect" between what is outlined in the Deci and Ryan [6] *Self-Determination Theory*, and what is actually occurring in our classrooms. In order to investigate this hypothesis, we must first determine what our engineering Faculty knows about SDT and its association with student learning. Since engineers are not generally trained to measure motivation, we invited our colleagues from Psychology to collaborate with us in designing a measurement framework based on sound principles and practices employed in the field of Social-Cognitive Psychology.

## A Perceived Problem in Educating Engineers

Twenty first-century engineering curricula are more and more disconnected with the changing engineering student demographics [13]. Common perceptions by the engineering Faculty are that their students are not excited about attending classes and spending time on school work, and many of them have insufficient technical knowledge and are not ready to do real engineering work after they have graduated [14]. When confronted with students with mediocre performance, the majority of engineering Faculty typically complains that their students are unmotivated or incompetent, and argue that the students have to be self-motivated in order to succeed the rigorous engineering standards. In contrast, the engineering students often complain they do not know why they are required to learn lecture materials that seem irrelevant and challenging,

especially the math content [15]. In addition, the students appear to be more focused on the outcome (grades), instead of the process (what and how they learn). More than ever before, new engineering Faculty have to balance outstanding research and effective teaching. According to [16], 95% of new Faculty take about 4-5 years of trial and error to become fully productive in research and effective in teaching. To have more time on research, Faculty would prefer the traditional Faculty-centered, lecture-based approach as it has been the standard means of transferring knowledge from Faculty to all students and it is perceived to incur less time for preparation if lecture notes are available.

Decades of education research suggest that active learning, problem-based learning, and collaborative learning can improve a broad range of learning outcomes, such as academic achievement and student attitudes, as compared to individual work. These studies [13,14,17,18,19] show that these learning methods can produce statistically significant gains in student learning (design skills, communication skills, and group skills), as compared to traditional instruction-based methods. However, these methods are not a "one-size-fits-all" solution for all faculty, and do not consider the situational factors associated with their classrooms [1]. The research team discussed this subject matter at length, and understand that while there is a wide body of literature on effective learning and teaching, there is a *disconnect* between what we know about motivation and learning, and what we actually do in our classrooms.

**Self-Determination Theory and its Impact on Academic Achievement**

Motivation has been the central theme in the field of psychology as it is the core of biological, social and cognitive functioning [6,20]. Much research has been carried out in the past few decades on assessing student motivation and its impact on academic achievement [20,21,22,23,24,25,26]. Many of the current motivation theories make an important distinction between an intrinsically and an extrinsically motivated behavior. Intrinsically motivated behaviors involve doing activities for the inherent pleasure of doing so whereas extrinsically motivated behaviors are generally tied to external consequences, such as rewards and punishment. Important research findings [6,20,21] associated with SDT suggest that three innate psychological needs - autonomy, competence and relatedness-which when satisfied can promote intrinsic motivation and when inhibited can stifle intrinsic motivation. Loosely speaking, *autonomy* can be thought of as having choices that are self-endorsed instead of driven by external control. *Competence* can be related 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. *Relatedness* can be thought of as a sense of purpose of pursuing certain actions or being connected to others in a social framework. Intrinsic motivation has been linked to various educational outcomes across the age span from elementary school to college students [27]. The research findings suggest that intrinsically motivated students are more likely to stay in school [28], and achieve positive academic performance as measured by standardized achievement tests and by teachers' ratings [24,25,26,27,28,29,30].

**Key Features of the Research**

To build on the conclusions reached by Dancy and Henderson [1] and to address the limitation of the traditional "development and dissemination" approach, we explore if simply improving the

Faculty awareness and knowledge of *Self-Determination Theory* (SDT) [6] has any beneficial impact on classroom learning environment, student motivation, and student learning. This approach will ensure that the *autonomy* of the Faculty is preserved, thus providing the Faculty with a multitude of solutions that may be employed within the specific learning environment. The key features of this research are summarized below:

1. At the core of the research is the *Self-Determination Theory* (*SDT*) of motivation developed by Deci and Ryan [6], suggesting that three innate psychological needs – *autonomy*, *competence* and *relatedness*–which when satisfied, can promote intrinsic motivation for learning. Therefore, simply stated:

$$\underset{\text{(autonomy+competence+sense of relatedness)}}{\text{Learning Environment}} \Rightarrow \text{Intrinsic Motivation} \Rightarrow \text{Learning} \qquad (1)$$

2. Faculty plays a critical role in the classroom and beyond in improving motivation and student learning experience [9]. Therefore, the knowledge of motivation theory must be disseminated to the Faculty. Accordingly, we add knowledge dissemination to Equation 1 as follows:

$$\underset{\text{(dissemination to Faculty)}}{\text{Knowledge}} \Rightarrow \underset{\text{(autonomy+competence+sense of relatedness)}}{\text{Learning Environment}} \Rightarrow \text{Intrinsic Motivation} \Rightarrow \text{Learning} \qquad (2)$$

3. The research approach (Equ. 2) is fundamentally different from the traditional "development and dissemination" model in which only the *product* of the educational research is disseminated to the Faculty for implementation. The "prescriptive" nature of the "development and dissemination" model tends to restrict the *autonomy* of the Faculty and does not consider the Faculty "situational factors" [1]. This is ironic because the student-centered approaches tend to increase the *autonomy* for the students, which in turn promotes intrinsic motivation.
4. Learning environment is a Faculty-student collaboration, and all components of the SDT must co-exist for all constituencies. The current approach preserves Faculty *autonomy* by not prescribing "what to do" but by simply informing "what improves motivation" such that the Faculty, who actually know what the situational constraints are, can successfully implement the model in the classroom environment.
5. It is hypothesized that there is disconnect between the principles outlined in *Self-Determination Theory* (SDT) and the actual classroom environment, thus creating a barrier to intrinsic motivation needed for student learning. The proposed work is an empirical investigation to explore this disconnect in the context of undergraduate engineering education. The primary tasks of the research are:
   (i) To assess the Faculty knowledge of SDT;
   (ii) To develop a measurement framework for assessing the classroom environment as it relates to SDT; and
   (iii) To determine the association among Faculty knowledge of SDT, student motivation, learning environment, and student learning.
6. A longitudinal, quasi-experimental design is employed where both instructors and students in the various Engineering Departments at Florida Atlantic University (FAU) are the participants. The research design and measurement framework (e.g. Learning Climate Questionnaire or LCQ; Riverside Situational Q-sort Version 3.15 or RSQ; Learning Self-Regulation Questionnaire or SRQ-L; etc.) are developed through a meaningful 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.

7. This study represents a synergistic partnership among Engineering, Education and Psychology. This collaboration is depicted visually in Figure 1 indicating the expertise of the three groups of collaborators and snippets of what each brings to research team.

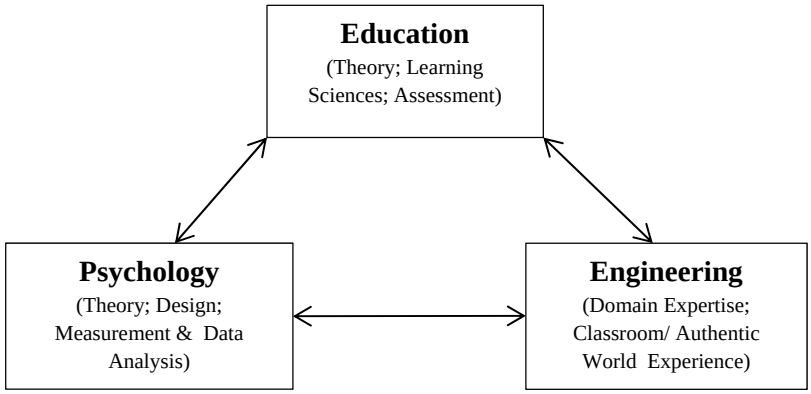


**Figure 1: Triangular Partnership for the Study of Engineering Education**

## Methodology

Previous research on motivation and student learning indicates that the relationship between classroom environment and learning outcomes is mediated by student motivation. This pattern is displayed graphically in the right three panels of Figure 2. However, to the three rightmost panels in Figure 2, we add the panel on the left hand side—Faculty Knowledge of SDT. This addition is important as we believe that it is this disconnect between what is known about student motivation and learning outcomes contributes to poor learning outcomes.

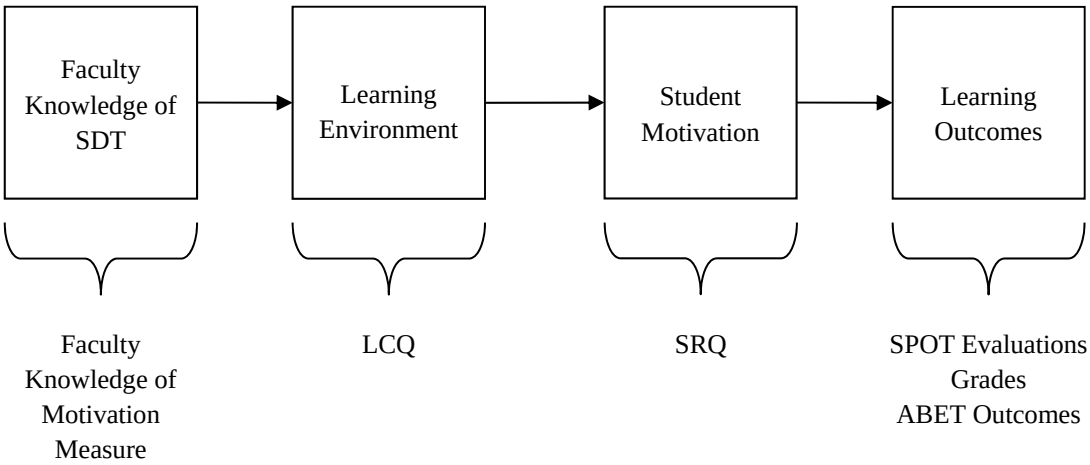


**Figure 2: Motivation Mediates Classroom Environment–Learning Relationship**

Drawing on this model, two important research questions and one hypothesis emerge.

***Q1: What do engineering Faculty know about SDT and its association with student learning?***
As Figure 1 demonstrates, Faculty knowledge of current research findings on motivation and its links to academic outcomes is a critical starting point in the process of learning for students. Thus, before any further research can be done it is necessary to understand what Faculty know and do not know about *Self-Determination Theory*.

***Q2: What do engineering Faculty do in their classrooms that may fulfill or neglect the needs identified by SDT?***
The second link in Figure 2 is really a question of what is currently being done in engineering classrooms. Do current instructional techniques create a learning environment that meets students' needs for *Autonomy*, *Competence*, and *Relatedness*? And if not, what is the impact of current practices (not SDT-related practices) on student motivation? Considering research questions 1 and 2 in conjunction, we see that there are conceptually four possible categories of faculty members. These categories are graphically depicted by Figure 3 below.

| | Low Knowledge of SDT | High Knowledge of SDT |
|---|---|---|
| Low Utilization of SDT | I | II |
| High Utilization of SDT | III | IV |

**Figure 3: Four Conceptual Categories of Faculty Members in Relation to SDT Knowledge and Utilization**

We suspect that most Faculty members will fall into category I (low SDT knowledge and SDT utilization). This is because engineering Faculty members at research institutions are not trained in the concepts of SDT as part of their graduate training and they are unlikely to have come across these concepts in their own research. We suspect that far fewer Faculty members will fall into the other three conceptual categories for a variety of reasons including perceived situational constraints stated by Dancy & Henderson [1].

***Hypothesis: Increasing Engineering Faculty Knowledge about Self-Determination Theory and its association with Student Learning will increase student motivation and learning.***

If the model we have proposed in Figure 2 is an accurate depiction of reality, we should find that simply increasing Faculty awareness of *Self-Determination Theory* and its connection to learning leads to changes in classroom environments such that they promote more intrinsic motivation in

students which in turn leads to increases in student learning. However, as we have noted previously, it is important that increasing Faculty awareness about SDT and its connections to motivation and learning be "non-prescriptive" in nature so as to not diminish the Faculty members' needs.

**Measures**

Addressing these two research questions and the hypothesis requires a number of measures. First we must assess Faculty knowledge about *Self-Determination Theory*. Second, we must assess the classroom environments. Third, we must assess student motivation. And lastly, we must assess academic performance outcomes.

*Faculty Knowledge of Self-Determination Theory:* To measure what the Faculty know about *Self-Determination Theory* and its association with student learning, we have adapted the Self-Regulation Questionnaire (SRQ; Table 1) to be from the Faculty point of view. This approach to creating this new measure is advantageous because it capitalizes on the pre-existing reliability, validity, and development of the SRQ. However, because this measure is new, we list the measure and its instructions here.

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* |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

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*.

*Classroom Environment:* To measure the classroom environments, we use the Learning Climate Questionnaire (LCQ) [32,33,34,35]. The LCQ consists of 15 items rated on a 1 (*strongly disagree*) to 7 (*strongly agree*) scale, which 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 Motivation*: To measure student motivation, we use the Learning Self-Regulation Questionnaire (SRQ-L) [32,33] which we have adapted specifically for engineering students. The SRQ-L consists of 12 items rated on a 1 (*not at all true*) to 7 (*very true*) scale. These items form two subscales measuring two types of motivation: *Autonomous* and *Controlled*. Autonomous motivation corresponds closely with the intrinsic motivation (example item: "The reason I will work to expand my knowledge of engineering is because it's a challenge to really understand how to solve engineering problems"). Controlled motivation on the other hand corresponds closely with extrinsic motivation (example item: "I am likely to follow my instructor's suggestion for studying engineering because I would get a bad grade if I didn't do what he/she suggests"). The full content of this measure can be found in the supplementary materials.

*Learning Outcomes*: Student learning outcomes is measured in three distinct ways. First, student learning outcomes is measured subjectively via use of one question on FAU's Student Perception of Teaching (SPOT) evaluations. The SPOT evaluations are given 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?" will be rated from 1 (*an exceptional amount*) to 5 (*almost none*). Second, student learning outcomes is measured objectively via final grades in the course, after statistically controlling for prior grades. A third measure of student learning outcomes takes advantage of FAU's College of Engineering syllabus policies and ABET's goals for engineering students. Specifically, the syllabi for <u>all</u> courses in FAU's college of engineering indicate 3-5 objectives students are expected to reach by the end of the course. Further, these objectives can be mapped onto ABET's objectives a-k. At the end of each course, students will respond to a question indicating their agreement about whether they have met that objective using a 1 (*strongly disagree*) to 5 (*strongly agree*) scale for each objective on the course's syllabus. Using thee 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 in Table 2.

**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} or Random Coefficient

Regression {RCR}) will be used [40,41]. At each measurement time point, students and Faculty will provide us with their FAU issued Z-number which serves as a unique identifier for each participant for each measurement period. This will ensure that proper statistical analysis can be conducted. The primary analyses will focus on the two aforementioned research questions and the hypothesis. To examine the first research question— *What do engineering Faculty know*

**Table 2. Measures Table**

| Measure | Description | Purpose | Assessment(s) |
|---|---|---|---|
| Faculty Knowledge of SDT Questionnaire | 12 items adapted from William & Deci [33] | Faculty Knowledge of Self-Determination Theory | From faculty beginning of Spring 2014 and Spring 2015 |
| Learning Climate Questionnaire (LCQ) | 15 items from William & Deci [33] rated on a 1-7 scale | Measure classroom learning environments | From students mid-semester in Spring 2014 and Spring 2015 |
| Learning Self-Regulation Questionnaire (SRQ-L) | 12 items from William & Deci [33] rated on a 1-7 scale | Measure student motivation (autonomous vs. controlled) | From students at beginning, middle, and end of semester in Spring 2014 and Spring 2015 |
| 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 Spring 2014 and Spring 2015 |
| Student Grades | Semester GPA on a 4.0 scale | A second measure of student learning outcomes | From university registrar at the end of Spring 2014 and Spring 2015 as well as grades prior to Spring 2014 as a control |
| ABET Outcomes | 3-5 items (varying by course) which can be mapped directly onto ABET's a-k objectives rated on a 1-5 scale | A third measure of student learning outcomes | From students at the end of semester in Spring 2014 and Spring 2015 |

*about SDT and its association with student learning?*—we will examine the mean scores on the aforementioned Knowledge of Motivation Theory Measure. Although there is no direct way to determine from this measure the "absolute" amount of knowledge Faculty has on this topic, this measure will be used first to identify the areas of SDT in which Faculty are deficient. These areas of deficiency will be the focus of the mid-study, Quasi-intervention FLC. Second, this measure will be used to examine how much Faculty learned about SDT prior to and after the intervention. These analyses can be conducted at both the individual item level of the "Knowledge of Motivation Theory Measure" as well as at the composite (e.g. Autonomous Regulation vs. Controlled Regulation) level.

The second research question— *What do engineering Faculty do in their classrooms that may fulfill or neglect the needs identified by SDT?*—will be examined by first quantifying the typical classroom environment. Second, we will examine associations between classroom environments and learning outcomes across all measured classrooms. The average scores on the Controlling and Autonomous subscales of the LCQ will be compared as one way of assessing the typical classroom environment. If the typical classroom is rated as more Controlling than Autonomous,

this would indicate that on average, Faculty are creating classroom environments that diminish intrinsic student motivation.

To test the hypothesis that— *Increasing Engineering Faculty Knowledge about Self-Determination Theory and its association with Student Learning will increase student motivation and learning* —a number of analyses will be conducted. First, because this study employs a longitudinal quasi-experimental design, we will compare Faculty knowledge about the associations between intrinsic motivation and learning before the intervention to Faculty knowledge after the intervention as a manipulation check. In addition, because many Faculty teach the same classes each semester, we will examine pre-intervention vs. post-intervention differences in classroom environments (as measured by the LCQ and RSQ). Finally, to examine the effect of the intervention on student learning outcomes, we will compare pre- intervention vs. post- intervention student learning outcomes. Because students and Faculty are nested in classrooms, and because this study employs repeated measures, multilevel modeling will be used to control for non-independence. The general MLM, following Raudenbush & Bryk [40], 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 will be 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 (LSQ) as a key variable, but also a number of control variables such as student gender, previous grades, and ethnicity. The intercepts and slopes for each classroom will then serve as outcomes in a regression at Level-2 (L2) and classroom-level predictors ($\omega$) such as faculty knowledge of self-determination theory (SRQ) and the quasi-intervention variable (dummy-coded) 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 [40,41]. 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.

**Study Timeline**

During each semester, the College of Engineering/Computer Science offers about 110 undergraduate courses across five engineering programs that are taught by approximately 70 Faculty members. Our study includes two waves of data collection corresponding with the Fall semesters of 2013 and 2014. The first wave (i.e. Fall 2013) of the data collection serves as a baseline in order to quantify what engineering faculty currently know and do in their classrooms in relation to *Self-Determination Theory*. After these data have been gathered and analyzed, we will offer a *Quasi-intervention Faculty Learning Community* (FLC) during the Fall 2014

semester, consistent and concurrent with the various ongoing FLCs sponsored by the University [12]. The main purpose of the FLC would be to inform the Faculty the results of the study thus far (e.g. report the mean Faculty knowledge of SDT; what students think the typical classroom environment is like), and 2) to inform participating Faculty about current research on *Self-Determination Theory* and its important implications for student learning. In particular, we will discuss the importance of meeting one's needs for *autonomy*, *competence*, and *relatedness* for optimal performance, how such ideas have been implemented in the higher education classrooms [32,33,37,38], and how they might be implemented in each individual engineering classroom. After the Quasi-intervention FLC, the spring 2015 semester of data collection will be used to examine changes in Faculty knowledge of *Self-Determination Theory*, classroom environment, student motivation, and student learning.

## Summary

The first wave of data collection started in October 2013. A total of 104 undergraduate students and 50 engineering Faculty in the College of Engineering and Computer Science at Florida Atlantic University participated in the study, and the preliminary findings will be presented in the NSF Grantees' Poster Session at the ASEE 2014 conference.

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