Work in Progress: Designing a Course to Promote Positive Learning Behaviors and Dispositions for First-year Engineering Students

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Introduction

We know that students who apply to competitive engineering colleges and universities excel on traditional measures of cognitive ability, such as GPA and standardized test scores. Despite these qualifications, however, many students leave engineering. Their reasons include excessive coursework and diminished interest[1], poor teaching and advising[2], and lack of confidence in mathematics and science skills[3]. Furthermore, there was no significant difference in academic performance between departers and persisters who started in STEM majors[1]. These findings suggest that we must look beyond students' academic ability to help students persist in engineering.

In this work-in-progress paper, we describe a design-based research project that explores how students adopt positive learning behaviors and dispositions through a course, because positive learning behaviors and dispositions have been shown to increase persistence through challenges and setbacks[4].

We have designed a course titled *Engineering the Mind* as an eight-week, second-half semester course that is offered for one semester-hour of credit. We plan to pilot this course in Spring 2017 to prepare for the Fall 2017 offering.

Background

Design-Based Research

Design-based research (DBR) is a research paradigm that attempts to bridge laboratory studies with complex, instructional intervention studies[5]. DBR is described as "theoretically-framed, empirical research of learning and teaching based on particular designs for instruction" (pp. 199-200)[5]. In DBR, we use theory to inform our course design and collect data to evaluate the desired student outcomes. DBR differs from laboratory experimental research in that DBR is situated in real-world contexts where confounding factors are difficult to control, whereas laboratory experiments aim to control for such factors[6]. DBR also differs from action research in that DBR applies theory in real-world contexts, whereas action research serves to solve an immediate problem that often involves the use of non-research personnel[7].

The outcomes of DBR include theory generation and practical educational interventions. Through our study, we will generate theory by documenting interactions between students, teachers, and the learning environment in the *Engineering the Mind* course. We will determine how well the transtheoretical model of behavior change can explain our results. We will collect quantitative and qualitative data to understand whether students have adopted positive learning behaviors and dispositions. In the end, we hope to create a practical educational intervention to help students persist in engineering.

Mindsets, goal orientations, and self-regulation

We use Dweck's implicit theory of intelligence regarding growth and fixed mindsets[4]. Students with the *growth mindset* believe that intelligence can improve with effort, whereas students with the *fixed mindset* believe that intelligence cannot be changed: they believe in innate talents. The growth mindset is considered an important component in promoting positive learning behaviors and dispositions, because it promotes success through effort.

Dweck also found that students with the growth mindset adopt a *mastery goal orientation*, in which they strive to master an academic subject whereas students with the fixed mindset adopt a *performance goal orientation* in which they aim only to earn a grade or to perform better than peers[8]. Mastery goal orientation has been associated with positive outcomes such as self-efficacy, persistence, preference for challenge, and self-regulated learning, whereas performance goal orientations has been associated with maladaptive patterns of cognition, affect, and behavior[9]. Students are described as self-regulated when they are "metacognitively, motivationally, and behaviorally active participants in their own learning process" (p. 329)[10].

Transtheoretical model of behavior change

We use the transtheoretical model of behavior change (TTM) as our overarching theory of change. TTM uses key constructs from other theories and applies them to explain behavior change in a variety of contexts[11]. We chose TTM because it is a theory of intentional behavioral change, and the purpose of our course is to change students' learning behaviors and dispositions. A major component of TTM is the stages of change model, which has five stages: Precontemplation, Contemplation, Preparation, Action, and Maintenance.

The stages of change model describes ten processes of change: five experiential processes and five behavioral processes (see Table 1). The experiential processes are primarily used during the early stage transitions (*e.g.*, from Precontemplation to Contemplation), whereas the behavioral processes are primarily used for the later stage transitions (*e.g.*, from Preparation to Action). In the next section, we explain how we will integrate these experiential and behavioral processes into the *Engineering the Mind* course in the form of lectures, in-class activities, small group discussions, and assignments using self-reflection.

Course Goals

We have two main goals for the *Engineering the Mind* course:
1) Understand how the brain works and the learning implications
2) Learn how to regulate learning to succeed academically

Goal 1: Understand how the brain works and the learning implications

To achieve the first goal, we will teach students about the different ways the brain perceives and interprets information. These brain processes are important for students to understand because the way the brain interprets information affects the way we learn.

Table 1. Ten identified processes of change in the stages of change model[11]

Experiential Processes	**Example**
1. Consciousness raising	1. Increasing awareness
2. Social liberation	2. Realizing the public system supports healthy behavior
3. Dramatic relief	3. Understanding emotions (fear, anxiety, hope, inspiration)
4. Environmental reevaluation	4. Noticing effect on others (negative or positive)
5. Self-reevaluation	5. Creating a new self-image
Behavioral Processes	**Example**
1. Self-liberation	1. Believing in one's ability to change and making commitments to change
2. Counter conditioning	2. Finding appropriate substitutes for negative behavior with healthy behavior
3. Reinforcement management	3. Increasing rewards for positive behavior, reducing for negative behavior
4. Helping relationships	4. Finding social support
5. Stimulus control	5. Managing your environment

Short lectures will be the first impetus of change in knowledge or beliefs. These lectures will last roughly 20 minutes and include activities based on classic psychology experiments. During these activities, students will personally experience how the brain works. For example, students will watch Daniel Simon's YouTube video about the "Invisible Gorilla." In this video, observers are asked to count the number of basketball passes. About half of the observers fail to notice a gorilla who walks across the basketball court, because they were so focused on keeping track of passes. By having students personally experience how the brain works, we hope to promote change through experiential processes: *consciousness raising* and *self-reevaluation*. We include mindsets and goal orientation theory into the conversation by emphasizing the importance of effort and how we can change through focused efforts, promoting the behavioral process of *self-liberation*.

Following lectures students will break out in to smaller groups to share about what they learned (or experienced) from lecture for the remainder of class. Instructors will provide prompts to promote discussion to help students connect what they've learned to personal application. We use small groups to be an integral part of the course in promoting change. Small group discussions promote a space where students can play a large role in influencing one another through diverse opinions, thoughts, and personal experiences[12]. We believe that small groups will promote change through the *helping relationships* process.

To assess whether students are learning about how the brain works, we will assign weekly *reflection papers* so that students express how the lecture, the classic experiment, and the small group discussion have influenced the way they view learning through provided prompts. The prompts will probe students on the following experiential processes: *self-reevaluation, social liberation, dramatic relief, and environmental reevaluations*.

In addition to weekly reflection papers, we will assign reading and watching assignments for homework. For example, students will read book excerpts and watch videos of TED Talks related to how the brain works. These readings and videos will be accompanied by short written

assignments called *reaction papers*. These reaction papers will have prompts designed to help students formulate thoughts and opinions before coming to class. In one sense, reaction papers are pre-reflection papers because reaction papers reveal students' initial thoughts and opinions, which may change after the lecture or after the small group discussion.

Goal 2: Learn how to succeed academically through self-regulation

We will use the same teaching methods for the second goal as for the first goal: students will listen to lectures that inform them about self-regulation and, afterwards, will break into smaller groups for discussion. The two main differences are that students will spend most of their time in their small groups, and that students will focus on *doing* rather than on reflecting. Each student will use this discussion time to develop a personal *strategy document*, describing their plans to succeed academically in a specific course for the following week.

We will provide a template of the strategy document that will include a list of considerations. This list will suggest making commitments, finding appropriate substitutes for bad study habits with good study habits, making a reward (or punishment) system for (not) achieving academic goals, finding social support, and managing a study environment. All these considerations pertain to the behavioral processes listed previously in Table 1.

Students will share their plans with one another to generate ideas and provide feedback. Each week, students will revisit their strategy document to evaluate how well or how poorly they followed their plans. They will make adjustments to their plans and provide justification for their new decisions. Students will be expected to use concepts learned from the course to justify their decisions.

We hope to answer the following research questions through our *Engineering the Mind* course:

1) Does our course help students adopt the growth mindset, mastery goal orientation, and self-regulation strategies?
2) How well does the transtheoretical model of behavior change explain how engineering students adopt the growth mindset, mastery goal orientation, and self-regulation strategies?

Methods

Consistent with DBR, we can answer our research questions robustly and in the context of the course by using multiple methods to collect data. The course will limit enrollment to a maximum of 30 students.

We will administer a pre- and post-survey that includes mindsets, goal orientations, and self-regulation, one survey at the beginning and one at the end of the course. To measure mindsets, we will use the implicit theories of intelligence subscale from Dweck[4]. To measure goal orientations, we will use the Performance-Avoidance (Revised), Performance-Approach (Revised), and Mastery Goal Orientation (Revised) scales from the Patterns of Adaptive Learning Scales (PALS)[13]. To measure self-regulation, we will use the Metacognitive Self-Regulation subscale as well as the Time and Study Environment subscale from the Motivated Strategies and Learning Questionnaire (MSLQ)[14]. The pre- and post-survey results will help us

answer our first research question on whether the course has helped students adopt these positive learning behaviors and dispositions.

To answer the second research question, we will collect qualitative data using students' reflection papers, reactions papers, and strategy documents. We will use these course artifacts to determine what experiential and behavior processes influenced their decision to change (or remain the same) with respect to the stages of change model.

These artifacts will be used to determine how students transition between the early stages of the stages of change model, for example, from Precontemplation to Contemplation or from Contemplation to Preparation. We will examine the strategy documents to determine how students change in their learning behaviors each week. These changes will reveal how students transition in the later stages of the Stages of Change model, for example, from Preparation to Action, or more interestingly, from Action back to Preparation.

Our research has been approved by the local Institutional Review Board (#17595).

Significance

Through our study, we hope to create a low-cost intervention to help students persist in engineering. Students who have adopted positive learning behaviors and dispositions will learn from difficulties and continue to pursue their engineering degree rather than becoming discouraged by failures and searching for another major. Furthermore, we will better understand what students believe about their intelligence and how we can promote positive change through TTM.

TTM has been used more commonly in a clinical context rather than an academic context. Interventions for mindsets and goal orientations have demonstrated that change can happen within one hour. However, we want to better understand how we can maintain the positive change as well. We will determine whether TTM's stages of change model helps us promote positive changes to students' learning behaviors and dispositions.

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