



WIP: Teaching Engineering Students How the Brain Works to Encourage Positive Learning Dispositions and Behaviors

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Introduction

Student attrition is a major concern of engineering programs. Only 49.7% of students who began in engineering in 2007 attained an engineering degree within 5 years [1]. Although some of the other students eventually earned engineering degrees, most departed engineering altogether. Students leave engineering for many reasons, including diminished interest [2], poor teaching and advising [3], and lack of confidence in mathematics and science skills [4]. In contrast, when students adopt a mastery goal orientation, that is, a focus on learning and developing mastery, they experience positive outcomes including persistence, self-regulated learning, self-efficacy, and general well-being [5]. In our study, we explored whether we could help students persist in engineering by encouraging such positive learning dispositions and behaviors.

In this work-in-progress paper, we report preliminary results from a one-credit course called “Engineering the Mind.” We used design-based research and the Transtheoretical Model (TTM) of Health Behavior Change to design the course and assess the outcomes. The goal of the course was to encourage students to adopt positive learning dispositions and behaviors by teaching them how the brain works.

Background

Design-based research (DBR) is a research method that evaluates theory-based interventions (that were developed in laboratory conditions) in complex, real-life contexts [6]. Consequently, DBR studies produce both theory generation and practical interventions. We used DBR in our study by applying TTM to “Engineering the Mind,” which was designed to promote change in learning dispositions and behavior. Details of the course design can be found in our previous paper [7]. TTM was developed using key constructs from other theories to describe behavior change [8]. TTM has been used to investigate smoking cessation, weight control, and exercise acquisition. TTM describes five stages of behavior change and ten processes of change.

To encourage positive learning *dispositions*, we used Dweck’s implicit theory of intelligence (mindset) [9] and goal orientation theory [10]. To encourage positive learning *behaviors*, we used self-regulation theory [11]. Students with the growth mindset believe that intelligence can be improved with effort, whereas students with the fixed mindset believe that intelligence cannot be changed [9]. Students with the growth mindset tend to adopt a mastery goal orientation in that they strive to develop competence [5]. In comparison, students with the fixed mindset tend to adopt a performance goal orientation in which they strive to earn a grade or to perform better than their peers. There are two types of performance goal orientations: performance avoidance and performance approach [10]. In performance avoidance, students avoid situations where they have to demonstrate their ability, whereas in performance approach, students want to openly demonstrate their ability to others. Self-regulation is a metacognitive behavior where students plan, monitor, and adjust their behavior to achieve tasks [11].

We investigated two research questions. First, can we influence students' mindsets, goal orientations, and self-regulation through the "Engineering the Mind" course? Second, how well does TTM describe changes in learning dispositions and behaviors in the context of the "Engineering the Mind" course?

Methods

Participants

We offered two sections of the "Engineering the Mind" course during the Fall 2017 semester at a large, public research university in the Midwest. There were nine students in one section and eight students in the other for a total of 17 students. All students submitted consent forms, which were collected by a graduate student who was unaffiliated with the course and sequestered until after final grades were submitted. At that time, we found that 15 students had consented to allow their data (i.e., their course assignments) to be used for research. Our research project was approved by the local Institutional Review Board (IRB#17595).

Data collection

We collected both quantitative and qualitative data from the students. For quantitative data, we administered a pre- and post-survey during the first and last week of the course, respectively. The survey had a total of 42 items. To measure mindsets, we included Dweck's Implicit Theory of Intelligence Scale (8 items) [9]. To measure goal orientations, we included the scales for Performance-Approach (Revised) (5 items), Performance-Avoidance (Revised) (4 items), and Mastery Goal Orientations (Revised) (5 items) from the Patterns of Adaptive Learning Scales (PALS) [10]. To measure self-regulation, we used the Metacognitive Self-Regulation scale (12 items) and the Time and Environment scale (8 items) from the Motivated Strategies and Learning Questionnaire (MSLQ) [11].

For qualitative data, we collected all course assignments: Reaction Papers, Reflection Papers, Strategy Documents, and Final Papers. Students wrote Reaction Papers to document their thoughts on TEDTalks and readings that were assigned as homework. Students wrote Reflection Papers to document their thoughts after in-class discussions and after reflecting on the week's topics. Students maintained Strategy Documents to plan and evaluate weekly academic goals (e.g., splitting up weekly problem sets into daily quotas). In lieu of a final exam, students wrote Final Papers in the form of a letter to their high school self (or to a friend in high school). These letters included what students wished they had known before coming to college and what students wanted to share from the "Engineering the Mind" course.

Data analysis

We used multiple methods to analyze the data because we wanted to capture various nuances of the course. For quantitative methods, we calculated the average score of the items for each scale for each student. For example, the mindset scale had eight items, each with a score ranging from one to six (Likert scale), and a student's mindset score would be the average score of the eight items. Then we used the Wilcoxon signed rank test to examine the score differences between the pre- and post-surveys. Among the students who consented to the research, one student did not

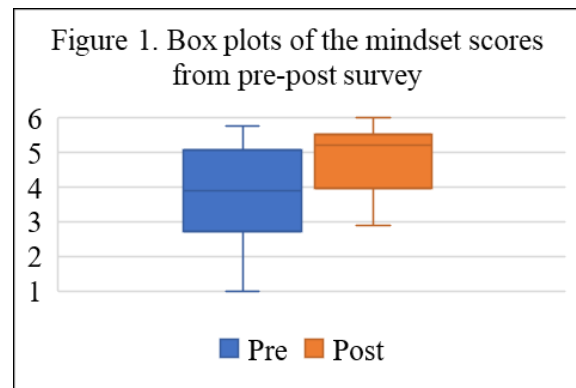
complete the pre-survey, and so, our sample size was reduced to $N = 14$. With our small sample size, we would be able to detect only large differences.

For qualitative methods, we used TTM as our theoretical framework to analyze students' course assignments. We used semi-open coding using the stages and processes of change from TTM for a priori codes, and we used open coding to capture unexpected data. Using these codes, we performed thematic analysis to identify what aspects of the course were salient and whether the design of the course supported the change process. Due to space limitations, we omit the qualitative results.

Preliminary Results

We summarize the results of the Wilcoxon signed rank test in Table 1. We chose a standard significance level of $\alpha = .05$. We found that there was a significant pre-post difference for only the mindset scale with a large effect size of $r = .57$ ($Z = 3.046, p = .002$) and a matched-pairs rank-biserial correlation of $r = .96$. The median mindset score increased from pre-survey ($Md = 3.88$) to post-survey ($Md = 5.19$). Figure 1 illustrates the increase in mindset score between the pre- and post-survey. Mindset scores that are 3.00 or below represent students with fixed mindset, whereas scores that are 4.00 or above represent students with a growth mindset. Mindset scores between 3.00 and 4.00 represent students with mindsets that do not lean toward one side or the other. These results suggest that the course helped students adopt the growth mindset by the end of the semester.

Scale	Z	p
Performance Avoidance	-0.882	.378
Performance Approach	-1.444	.149
Mastery	-1.149	.250
Mindset	-3.046	.002
Metacognitive Self-Regulation	-0.595	.552
Time & Environment	-1.654	.098



Significance

TTM has primarily been used in clinical contexts to investigate health behaviors such as smoking cessation and weight control. Our study applied TTM to the academic context to encourage positive learning dispositions and behaviors. Though not presented in this paper, we expect that our qualitative analysis will reveal more than our quantitative findings. We plan to generate theory on how TTM applies to the academic context.

Based on the pre-post survey results, the “Engineering the Mind” course helped influence students to adopt the growth mindset. However, we saw no statistically significant pre-post differences in goal orientation or self-regulation scales. Adopting the growth mindset in of itself does not imply that students are more likely to persist in engineering, but it may be the first step

in helping students persist. We recognize that change takes time and that follow-up courses may be necessary to help students adopt more positive learning behaviors.

We plan to develop follow-up courses to help students continue to apply what they learned in the “Engineering the Mind” course. We also plan to track students over time to determine whether these courses help retain engineering students. If these courses are effective in retaining engineering students, then other institutions could adopt them to help retain their students.

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