The Future of Engineering Education
2024 Annual Conference & Exposition
Oregon Convention Center
Portland, OR . June 23 - 26, 2024
ASEE
Paper ID #43375

Board 426: Work in Progress: Real-Time Ecological Momentary Assessment of Students' Emotional State in Statics

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Abstract

This paper/poster shares the initial findings of an Ecological Momentary Assessment (EMA) study conducted in an undergraduate engineering mechanics course (Statics) at a 4-year university. Like many early undergraduate engineering courses, Statics is notorious for high attrition and often stifles students' subsequent persistence in engineering programs. The objective of the study described herein is to identify links between students' self-efficacy, motivation, emotional states, and other factors that may serve as early-warning indicators of dropout.

The EMA approach utilizes repeated experience sampling of students' psychological state using cell phone-based polling. Sampling is conducted on a semi-daily basis as well as proximal to high-stakes assessments. Unlike prior studies that only measured students' psychological state twice (at the start and end of a semester), this study is unique in that it measures a broad range of psychological variables repeatedly (up to 65 times over 17 weeks). The surveys utilized in this study include validated instruments such as PANAS, MSLQ, APPLES, as well as new instruments specific to learning outcomes in Statics that have been developed by the authors. Preliminary quantitative results suggest that (a) students' emotional state rapidly declines once the semester begins, (b) negative affect remains worse than baseline throughout the semester, (c) students' weekly change in negative affect after the 4^{th} week of the course may serve as the best predictor of their persistence and final grade in the course. These observations are generally true for all students enrolled in Statics regardless of their final grade. The study is ongoing and will be replicated in future studies to increase the relatively small samples size, which is the primary limitation of the current findings.

Keywords

affect; emotion; engineering formation; motivation; persistence; research initiation; RIEF; self-efficacy; statics

1. Introduction

This paper presents initial findings of a study conducted to identify links between student's psychological state of mind and their academic performance and persistence over the course of a semester in a Statics class. It is well known that students perceive Statics as a "threshold" or "weed out" class due to its low passing rates [1, 2] that are often below 70%. Students who are unable to pass the course may ultimately withdraw from an engineering major. As a result, persistence and retention in engineering is hampered, which is typically magnified in underrepresented groups.

The primary goal of this research is to identify links between students' self-efficacy, motivation, emotional states, and other factors that may serve as early-warning indicators of dropout. The research is based, in part, on the fundamental concept of self-efficacy from Social Cognitive Theory (SCT) [3]. Self-efficacy refers to a learner's belief in their own ability to succeed in the completion of tasks. SCT asserts that a learner's self-efficacy significantly affects their subsequent behavior by influencing (a) their decision-making, (b) the amount of effort they exert to complete a task, and (c) their persistence to complete a task despite failure. Kuzbary et al. [4] provided "*... evidence that students with positive perceptions of the future are more persistent toward their goals ...*".

The three subscales or components of self-efficacy are (1) cognitive, (2) motivational, and (3) emotional processes [5]. Each component feeds into a student's overall sense of self-efficacy.

1. Cognitive factors refer to the learning beliefs that students have about learning a subject, such as Statics.
2. Motivation is based on a learner's initiative or desire to achieve specific objectives [6].
3. Emotional processes refer to affect (a person's emotion), which includes positive and negative feelings as well as anxiety. The term affect is used in this paper since it is an umbrella term encompassing all emotions and moods.

Each of the three intrinsic components can significantly affect students' performance in Statics [7, 8]. Of the three, emotional processes are the most dynamic and exhibit the most frequent changes over time [5]. As a result, variations in emotional processes can lead to subsequent changes in motivation and cognition.

Changes in self-efficacy are typically subtle, but changes in affect tend to be more dramatic and frequent. If a negative affect (i.e., feelings of distress) is sustained over time, it can accumulate as 'damage' to one's self-efficacy. This is analogous to the phenomenon of creep damage in structural concrete, namely, cracking and deformation will continuously worsen when a constant force is sustained over time. The practical implication is that changes in affect may serve as the earliest indicator of downstream changes in self-efficacy.

2. Research Goal

The overall goal of the study is to establish causal links between Statics students' self-efficacy, affect, and other major variables such as time, demographics, rigor of course content, and psychological stressors.

3. Research Methodology

The research approach is to conduct an Ecological Momentary Assessment (EMA) study, which involves frequent self-reporting of participants' behaviors and affect in real-time at periodic intervals [9]. Also known as "experience sampling", this approach utilizes electronic polling (via text message) to collect students' affect and self-efficacy in real-time on a recurring schedule and around examination times. Polling can improve student participation and serve as an effective feedback loop [10-12].

Validated psychometric test instruments were utilized to measure affect, self-efficacy, motivation, and engineering identity. Since changes in affect may serve as the earliest indicator of downstream changes in self-efficacy, it serves as the primary response variable under investigation. Summaries of the survey instruments are provided below; the complete instruments can be obtained using the references cited.

- The Positive and Negative Affect Schedule (PANAS) measures positive affect (PA) and negative affect (NA) [13] emotional responses at a given point in time. When responses are given before and after personally significant events, such as taking exams and receiving grades, the difference in response can provide valuable insight. Only a subsample of five PA scales (such as "happy" and "content") and five NA scales (such as "sad" and "anxious") were selected so as to not overwhelm students with too many survey questions. Additionally, participants were asked to (a) identify prevalent psychological stressors from a drop-down list and (b) rank the severity of each on a Likert scale from 0 to 10. Identifying these stressors could help identify confounding events that occurred during the semester.

- The Motivated Strategies for Learning Questionnaire (MSLQ) assesses participants' self-efficacy, as well as motivation and learning strategies [14, 15]. It consists of 44 items, each with a response in the form of a rating on a 7-point anchored Likert scale where 1="not at all true of me" to 7="very true of me". Only a subset of the survey (10 items) were selected for this research study to minimize the burden on students due to the frequency of the survey administration.

- The Academic Pathways of People Learning Engineering Survey (APPLES) characterizes the factors influencing undergraduate students' persistence in engineering with categorical and Likert scale responses [16]. Of the 51 questions in the full survey, 9 were selected in this study.

- To capture engineering identity (EIT), the tool developed by Godwin et al. [17, 18] was used. The tool has 23 questions, and responses are configured using an anchored Likert scale where 0="strongly disagree" to 6="strongly agree". 11 questions were selected for this study.

Custom surveys were created to capture unique information such as demographics, family background, and students' perception of their knowledge of Statics course content.

- A Demographics and Family Background survey collected gender, race, ethnicity, age, major, progress (year) in each student's curriculum, annual family income, Expected Family Contribution (EFC) as a measure of financial health, and whether the student is a first-generation college student (FGCS).

- The Self-Assessment of Statics Skills (SASS) is a set of 14 Likert-scale surveys, each soliciting the students' perception of their confidence to complete a task relevant to Statics course content taught during each week of the semester. For example, one question asks students to rate their confidence to "Apply the Parallel Axis Theorem to calculate the moment of inertia of simple shapes and composite areas about a specified axis." These knowledge surveys were adapted from work reported by Davishahl [19].

Finally, exam and final course grades were collected and analyzed to identify trends for two student cohorts: #1: students earning an A, B, or C; #2: students with an F or withdrew from the course (W).

Data sampling consists of sending students an SMS text message with a URL link to the self-reporting surveys. Full surveys were typically administered at the start and end of the semester, while the abridged versions were administered on a semi-daily or weekly basis. The sampling frequency varied according to a schedule for each of the instruments:

1. PANAS is administered three times per week to assess emotional state during daily life. Then, along with MSLQ: once before and once after each major exam, and then every 12 hours for four days while students wait for their exam grade (rumination phase). This results in about 80 sampling data points per student.
2. At the end of each week (Friday), a SASS survey is administered to assess students' knowledge and confidence of the new Statics content taught during that week. This data can help identify which course topics the students are struggling to comprehend.

4. Results and Discussion

Preliminary data collected during the 17-week fall 2022 semester is summarized in Figures 1 and 2. Of the 34 students enrolled in Statics that semester, 21 (62%) participated in the research study. If students received a passing course grade, their participation in the study was compensated with extra credit (up to 4%) added onto their grade.

Figure 1 shows that students' positive affect decreases immediately at the start of the data collection, which is at the end of the second week of class, and remains below this baseline for the remainder of the semester with F and W students showing larger decreases. Similarly, Figure 2 shows that students' negative affect levels increased at the start of the study and generally remain higher for the cohort of F and W students throughout the semester.

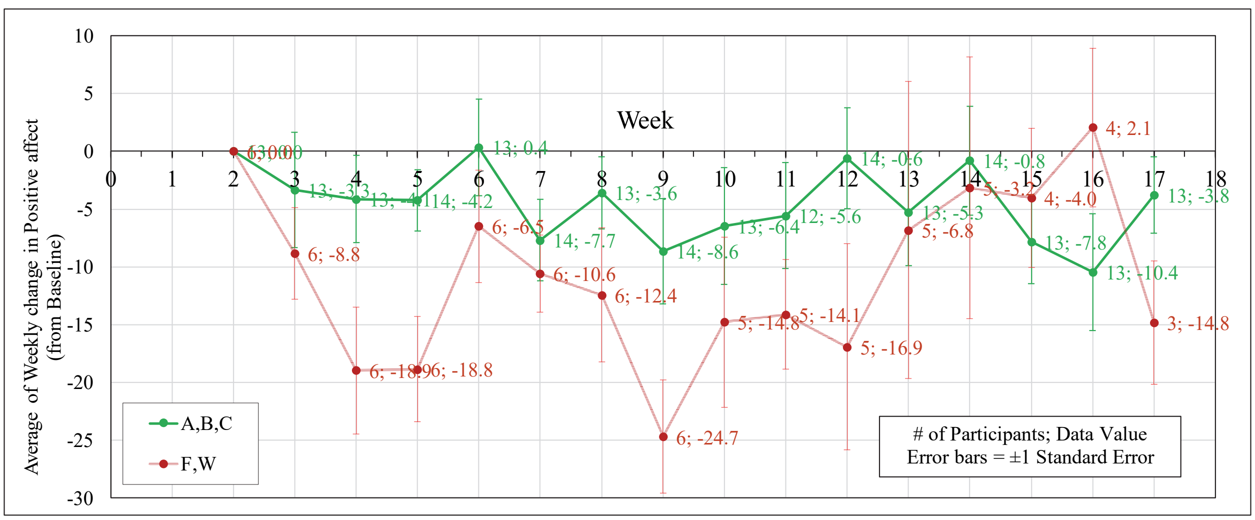

Figure 1. Weekly change in positive affect (from baseline in week 2) in Fall 2022; two cohorts are based on final course grade

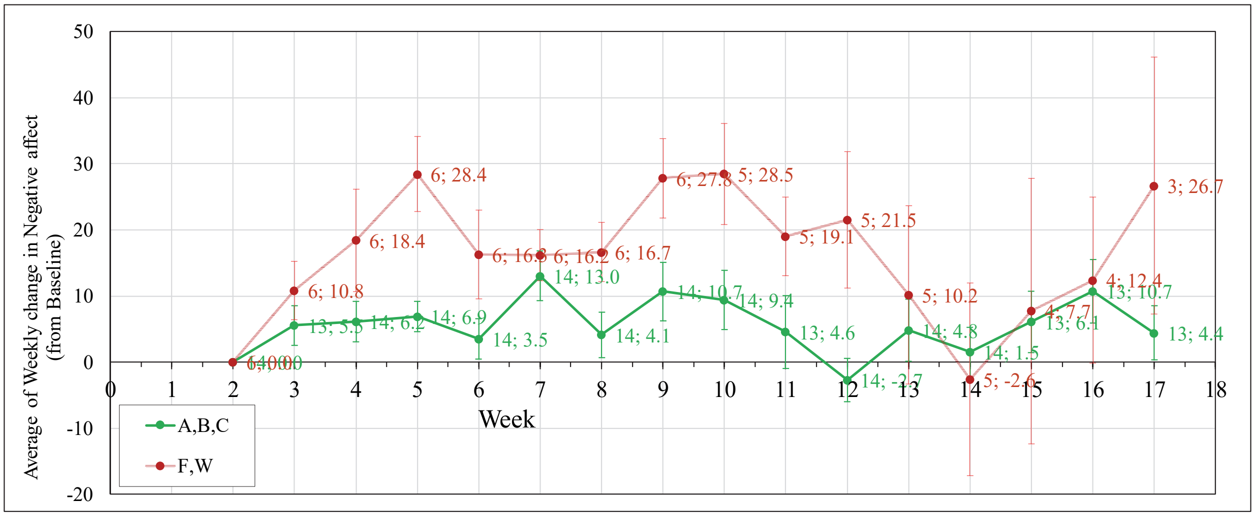

Figure 2. Weekly change in negative affect (from baseline in week 2) in Fall 2022; two cohorts are based on final course grade

Finally, the data in both figures suggests that students' weekly changes in both positive and negative affect during the 5th week of the course may serve as the strongest predictor of their persistence and final grade in the course. These weeks typically coincide with the administration of major exams in Statics and in other core courses such as Physics, Calculus, and Chemistry.

5. Conclusions and Future Work

The ongoing research utilizes an Ecological Momentary Assessment (EMA) study to repeatedly measure students' emotional state. Based on preliminary data, changes in positive and negative affect in the first few weeks of the course may serve as an early indicator of whether students will be successful in the course. This study is being repeated in the Fall and Spring semesters to collect additional data to generate more robust conclusions. The affect data will be analyzed along with data from the other survey instruments to explore the relationships between cognitive, motivational, and emotional processes on self-efficacy as it relates to academic persistence.

6. Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. 2204892. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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