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CAREER: Informing Instructional Practice through the Study of Students' Future Time Perspectives

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Abstract

This research seeks to help educators understand factors that contribute to engineering students' motivation and the relationship between those factors and their problem solving processes. Understanding these relationships will aid researchers and practitioners in preparing students for a future of complex problem solving in the face of rapid technological change and globalization. This project addresses these research questions: What motivational attributes that characterize engineering students are relevant to their problem-solving skills and self-regulated learning? How do these relationships change over time? How do they differ between engineering disciplines?

In our preliminary quantitative study, we developed the Motivation and Attitudes in Engineering (MAE) survey using achievement motivation as our theoretical framework. This study showed that a key factor in student success and learning is their motivation towards their future goals, especially with respect to career options. The relationships between that motivation and their activities in the present can be used by educators to increase interest in engineering, increase the relevance students see in their course activities, and prepare students to become effective engineers. These relationships were further explored through a series of qualitative studies, in which we identified three characteristic ways that students perceive their future goals and how those goals influence what they are doing in the present. Distinguishing characteristics between the three groups are depth into the future of their long-term goals, level of clarity with which students can describe their future, their ability to identify contingent steps needed to reach their goal, and what they perceive to be relevant and useful in the present to reaching their future goals.

Students within these different characteristic ways of perceiving the future respond differently to classroom activities. For example, when asked about what they think an engineering problem is, students with distinct future goals and who make connections between future and present tend to think of engineering problems as being well-structured and having clear right/wrong answers. Students with ill-defined futures and no connections between future and present see engineering problems as "anything" and tend to approach them conceptually. These insights will allow educators to better understand the students in their classes and to design activities and assignments that students will find relevant and meaningful. The study will continue to explore

the different ways that the MAE survey can be used to benefit practitioners and instructors. Currently, the MAE is being used to research connections between motivations of students and their behaviors in the classroom, including regulating their learning and solving complex problems. It is also being used for the purposes of a longitudinal research study on how motivational attributes change over time.

Introduction

Student motivation is a major factor in the development of metacognitive and problem solving skills. A key factor in student motivation is their perceptions of their future possible selves, which are also linked to cognition and perceptions of themselves in the present.[1-2] Understanding factors that contribute to students' Future Time Perspectives (FTP), such as expectations, values, and goals, as well as their metacognitive and cognitive attributes, will help engineering educators prepare students for solving complex, open-ended problems such as those they will face in a future of rapid technological change and globalization.

The study presented here is part of a larger, multi-phase mixed methods study, the goals of which are to answer the following research questions:

- RQ1: What factors contribute to students' motivation to pursue engineering?
- RQ2: How do motivational attributes correlate to learning and cognition in engineering, especially problem-solving and knowledge transfer?
- RQ3: How do motivational attributes change over time as knowledge, experience and skills in one's field develop?
- RQ4: What relationship, if any, do the particular aspects of bioengineering (BioE) and mechanical engineering (ME) have to motivation, learning, and cognition in those disciplines? How do these relationships compare between the two disciplines?

This paper serves as an overview of the ongoing quantitative and qualitative research to address these research questions. Additionally, more detailed descriptions of the qualitative research that addresses RQ2 are provided elsewhere[3-4].

Background

The theoretical framework of FTP served as the basis for the study of factors contributing to students' motivations towards their futures, their perceptions of their present tasks in their engineering studies, and the interactions between the two[1]. Another theory that has emerged as significant in describing engineering student motivation is possible selves[2], which examines students' goals in terms of who they want to become ideally (ideal self), who they think they can become (attainable self), or who they want to avoid becoming (avoided self). Research applying theory related to students' possible selves has shown that students with differing perceptions of their future will pursue goals differently. Students with ideal selves are more likely to persist when faced with challenges or difficulties in their lives[5]. Being future-oriented or working to develop perceptions of future possible selves has been shown to increase interest and efficacy to succeed in school[6], and can influence self-regulatory behaviors[7] and knowledge building [8].

Our research group established the MAE survey based on FTP, possible selves, goal orientation[9] and identity[10]. Our preliminary quantitative studies established the reliability and validity of MAE survey data collected from second year engineering students[11] and determined which constructs were relevant to engineering students' major choice[12]. The MAE was further refined through focus groups, psychometric analyses, and iterative factor analyses; results obtained with first year engineering students was validated as part of a study of outcomes of STEM living/learning communities[13]. Refinements to the survey include adding items related to goal orientation, which emerged from the analysis of interview data. We have also added a section on problem solving self-efficacy, a student attribute that we theorize will be important in connecting student motivation and problem solving and which will serve as an outcome for the structural equation model we will be building.

The purpose of this paper is to outline two major areas within the project that address each of the research questions, including initial qualitative studies to identify and characterize factors that are relevant to engineering student motivation, and quantitative studies to develop and test the MAE survey. Finally, we lay the groundwork for future studies that will determine how motivation attributes of students in different engineering majors change over time, and how their self-reported perceptions of problem solving change as well.

Project Activities and Findings

Identifying factors that are relevant to engineering student motivation:

Through interviews with second year engineering students reported previously[14], we are visualizing students' future perceptions as three different shapes of cones, with the base representing the present and the tip representing the future. Within each cone shape, there are differing ways that students do or do not make connections between the future and present. These interviews also explored students' perceptions of engineering problems and their approaches to solving them. Students with highly defined goals and specific career plans beyond graduation are visualized as relatively narrow cones that come to a well-defined point, extending relatively far into the future. These students value working on well-defined problems, and approach those problems in a linear, sequential fashion. Some students describe a broad range of possible future selves, and perceive many different current experiences as being instrumental to their future; their cone is wide in the present dimension, narrowing to a point in the future. The third type of student has vague or unclear notions of their future, which we visualize as a truncated cone (representing the lack of definition into the future beyond graduation). These students describe engineering problems as being "anything," tend to focus on concepts rather than a step-by-step approach to solving them, and do not see connections between their future selves and what they are doing in the present [14].

Our qualitative analysis also revealed that not all students see connections between their futures and the work they are doing in their courses; additionally, these connections can go both ways (present activities influencing future goals, and vice versa). Students in the second cone type (wide present dimension) articulate ideas about not only what they *want* to become in the future, but also what they want to *avoid* in the future. This feature distinguished this type of student from others.

Another interesting finding from the qualitative data is how students define failure within the context of their engineering studies. In response to the interview question, "How do you define failure?" students' responses varied in some form of being in a state of stagnation (not improving), stopping (giving up), or being unsatisfied with their performance (not doing as well as they wanted to). Some students described wanting to improve and learn something every day, and to these students failure is not improving, or stagnation. Katerina demonstrates this in her interview by defining failure as "Not seeing any progress in the positive direction." Students also described stopping as giving up before reaching their goal. For example, Matt describes failure as giving up on a problem:

> "It's not so much that you got it [the problem] wrong, I wouldn't say, really when you do something wrong I wouldn't say that's failure. I'd just say when you decide that enough's enough and you just won't do it anymore, like that's failure." –Matt

This description emphasizes the difference between stopping and being unsatisfied with one's performance. Matt describes that getting the problem wrong is not necessarily a failure, but in contrast, Silas defined failure as "doing poorly on an exam or getting a question wrong."

A few students articulated what happens beyond failure. These students described failure as a potential learning experience and the opportunity to improve skills or study habits. The idea of failure as a state of stagnation or of unfavorable performance has implications for how students perceive progress towards goals. If students perceive their futures as a set of contingent tasks, failure at a task or step along the path means their goals are farther away or even unattainable. An area for future research in this project is exploring the ways students respond to failure in terms of how they perceive their goals and their current tasks in engineering courses. Another avenue for exploration is examining students' perceptions of failure relative to their self-reported goal orientations and future time perspectives.

Our understanding of factors that contribute to students' motivation to pursue engineering (RQ1) continues to inform the refinement of the MAE survey. We are continuing to test the MAE survey for reliability and validity with first and second year engineering students. We have written new items for the MAE that will serve to distinguish between the different types of future possible selves that have emerged from our qualitative analysis. We tested validity and reliability of the new items through two focus groups (face validity) and one-on-one interviews with volunteers who took the survey and participated in follow-up interviews about its contents (external validity).

One key outcome from these activities was defining appropriate applications of the MAE survey, namely for research purposes rather than for use by educators in classrooms (although results from research using the MAE are certainly valuable for practitioners). The purpose of the MAE survey is not to "profile" students' motivation in the classroom, but rather to select students with different characteristic motivations based on quantitative data, for inclusion in other qualitative and mixed methods studies.

Conceptual replication of qualitative research studies on characterizing engineering students' FTPs:

A conceptual replication study (one that applies similar methods to different data[15]) was conducted with the goal of testing the underlying hypothesis of three categories of students' FTPs and future possible selves[16]. A Directed Content Analysis (DCA) method was used to replicate the IPA based results used in previous research[17]. DCA was used in this study for the validation of *a priori* codes and the need to allow new themes to emerge from data collected in a new population[18]. The replication population was seven self-selected participants (four of whom were female) from students who completed a survey (n=332) on student motivation in a different population from the original study: an introductory engineering class at a Western land-grant institution. Participants were given a $20 Amazon card as incentive for participation. Students completed a semi-structured interview focused on FTP and future possible selves. Questions prompted students' ideal futures, realistic futures, avoided futures, future outcomes (results of future career), and perceived instrumentality (relevance in present tasks towards future goals). Students were also asked what they wanted out of engineering and what parts of their education they felt were relevant to their future careers. Transcribed interviews were coded by two to three members of the research team using RQDA[19]. Codes were synthesized into themes (cone types) using previously defined classifications with explicit consideration of how emergent themes did or did not fit with our previous findings[17].

Results of this work[16] indicated that two of three cone types held for this new, but related, population: those with detailed descriptions of their future possible selves and well-defined FTPs that extend far into the future, and those with vague perceptions of their future possible selves and FTPs that do not extend far past graduation. Those in the first group were able to describe connections between their present actions and future career goals, and perceived instrumentality of present tasks in attaining their desired future. Those in the second group whose future possible selves extended a limited distance into the future were not able to connect their future goals to present actions, and perceived all tasks as potentially useful towards their ill-defined futures.

The relevance of these findings lies in the influence of students' perceptions about the future on their learning. Prior research in FTP has shown that students with detailed FTPs are more likely to use strategies that promote learning and engagement with material. Instructors should consider ways to facilitate student reflection on how classroom activities are connected to their FTPs to increase the relevance of present tasks, thus increasing their motivation to achieve. Students who have limited understanding of college environments or engineering as a major and profession may also need additional assistance in structuring FTPs and future possible selves. As such equipping students with self-crafted working definitions of engineering or their enrolled major as a profession can help these students determine their future in the field and use their future for developing important skills through present experiences.

In addition to replication of previous results, the classifications that emerged from this study may be better represented as a continuum than static categories of cone shapes. Further exploration of how students use episodic thinking in their construction of FTPs may allow for additional insight into students' experiences in engineering learning environments.

Future Work

We will continue testing and broadening the implementation of the MAE survey in different engineering student populations. We will expand the quantitative and qualitative studies to further test and magnify our findings, and explore how engineering students' FTPs affect their self-regulated learning strategies and processes, particularly sub-goaling[4]. We will focus on completing a large portion of the longitudinal study by doing follow up surveys and interviews with students who took the MAE survey as first year students 2 and 3 years ago. In addition, we will complete a confirmatory factor analysis and create a structural equation model of factors contributing to student motivation. We will conduct an exploratory factor analysis on the new items that we hope will distinguish between characteristic future possible selves, using data collected from about 300 second year engineering students. Future directions for this project include the effects of students' perspectives on failure on their attitudes towards their engineering studies, which can inform the design of engineering curricula to explicitly address the role of failure in developing engineering expertise.

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