What Does "Motivation" Really Mean? An Example From Current Engineering Education Research

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***Abstract**: Motivation is a popular research construct in engineering education but it is not always clear what is meant by "motivation". The current engineering education literature surrounding motivation is largely exploratory or without a theoretical framework. This paper highlights the potential value of motivational frameworks in engineering education research in two ways. First, this paper introduces the rich history of theoretically grounded motivational research within the field of educational psychology and draws connections to potential research areas within engineering education. Second, this paper provides a practical example illustrating how one particular theoretical framework of achievement motivation, Eccles' expectancy-value theory, informed the design and data analysis of a study related to persistence. The qualitative, longitudinal study examined ten engineering students' perceptions of themselves as future engineers, their achievement-motivation beliefs in pursuing engineering, and how these perceptions and beliefs changed from the first to the fourth year of college.*

Introduction

The term "motivation" is used frequently in engineering education research. In many cases the existing research is largely exploratory and without a theoretical framework. Connection to theoretical frameworks is an important part of advancing the quality of research in any field and has recently been highlighted as a need in the emerging field of Engineering Education (Borrego, 2007b) and in related fields such as Computer Science (Singh, Allen, Scheckler, & Darlington, 2007). This paper seeks to highlight the value of motivational frameworks in engineering education research by 1) introducing the rich history of motivational research within the field of educational psychology, and by 2) showing how research in engineering can connect to and expand this research heritage using an example from current engineering education research.

Motivational Theory Within Educational Psychology

As a construct within educational psychology, motivation, or achievement motivation, directly connects to theories that attempt to explain action in terms of an individual's beliefs, values and goals (Eccles & Wigfield, 2002). Eccles, Wigfield and Schiefele (1998) define achievement motivation as "the motive related to performance on tasks involving standards of excellence"(page 1017). Achievement motivation is what prompts individuals to engage or not engage in tasks or activities such as studying for exams or earning a college degree. Achievement motivational theories attempt to explain these choice processes. Engineering education research could benefit from connecting to and building upon these existing theories, which are extensively used in educational and developmental psychology research. In a review of current motivational theories, Eccles and Wigfield (Eccles &

Wigfield, 2002) used four categories including 1) theories focused on expectancy, 2) theories focused on reasons for engagement, 3) theories integrating expectancy and value constructs, and 4) theories integrating motivation and cognition. While there are many examples, only one example from each of the first three categories is presented to provide a sampling. The fourth category represents a group of theories that combine motivational constructs with cognitive constructs, such as self-regulation, and are beyond the scope of this paper.

Self-Efficacy

Self-efficacy is an example of the theories that focus on competence/expectancy. The premise of self-efficacy theory is that choices to engage in activities are based on an individual's perceived competence with regard to that activity (Bandura, 1997). Competence beliefs are developed through four primary sources including ones own experiences attempting a task (mastery experiences), observations of others attempting the same or similar tasks (vicarious experiences), feedback from others regarding one's competence (social persuasions), and feelings experienced while engaged in the task such as anxiety, happiness, etc. (physiological states). Self-efficacy theory provides an example where engineering education researchers have built on and connected to previous work to study classroom engagement and persistence choices (for recent examples see Hutchison, Follman, Sumpter, & Bodner, 2006; Marra, Rodgers, Shen, & Bogue, 2009).

Self-Determination Theory

Self determination theory focuses on reasons for engagement. In this theory, Deci and Ryan (Deci & Ryan, 2000; Ryan & Deci, 2002) posit the importance of competence, autonomy and relatedness needs in determining motivated choices of action. The need for competence is a desire for mastery. The need for autonomy is a desire to be in control of one's actions. Relatedness is a desire to fit with others or to be part of a group. These needs can contribute to both intrinsic and extrinsic motivations (Deci & Ryan, 2000).

Examples of research findings in educational and developmental psychology using a this framework include demonstrations that 1) intrinsic motivation can be undermined by extrinsic rewards (Deci, Koestner, & Ryan, 1999), 2) children of parents who support autonomy and relatedness have greater internalization of school-related values (Grolnick & Ryan, 1989), and 2) greater self-motivated academic behavior and well-being was predicted among high school students perceiving greater autonomy support from parents and teachers (Chirkov & Ryan, 2001). Similar issues, such as supporting autonomy and relatedness or intrinsic verses extrinsic rewards, are also important in engineering education classrooms yet little research in this field has applied this framework.

Expectancy-Value Theory

Eccles and her colleagues developed an expectancy-value model to explain psychological and social factors that contribute to gender differences in educational and occupational choices particularly in math, science and engineering fields (Eccles, 2007b; Eccles, et al., 1983). Within this model, the choices to engage in tasks are based on an individual's competence beliefs with regard to that task and the subjective value or importance he or she places on successful achievement of that task. For example, a student who believes he or she is competent in math and/or believes that math is interesting or potentially useful in future courses is more likely to enrol in an advanced math class.

Using Eccles model, educational psychology researchers have shown patterns as elementary and secondary school children develop competence and value beliefs and how these change with time (Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002 Eccles, & Wigfield, 2002). Among college students, researchers have predicted outcomes, such as course selections and occupational choices (Eccles, Barber, & Jozefowicz, 1999; Frome, Alfeld, Eccles, & Barber, 2008; Wigfield & Eccles, 2000), examined college women's intentions to pursue advanced degrees (Battle & Wigfield, 2003), and examined gender differences in college students' career choices (Eccles & Vida, 2003). Several researchers have recently begun using this framework within engineering education (Heyman, Martyna, & Bhatia, 2002; Li, McCoach, Swaminathan, & Tang, 2008; Matusovich, Streveler, Miller, & Olds, accepted for 2009) although more work is needed specifically with regard to associations between values and task engagement and persistence.

An Engineering Education Example: Persistence Framed in Achievement Motivation Theory

Theory Applicability

As previously mentioned, many motivational theories could be applicable to a variety of research topics within engineering education. Here we present Eccles' (1983) expectancy-value theory used in a study of persistence as an exemplar. While not the only potential example, persistence choices are a topic of current interest within the field of engineering education as evidenced by recent publication trends. Seven recent issues of JEE (January 2007 through July 2008) included eight articles related to attracting and retaining students in engineering. Additionally, persistence research in engineering education demonstrates the need for connection to theoretical frameworks. Of the eight articles previously mentioned, only two explicitly identified theoretical frameworks. The two identified frameworks were motivational and included self-efficacy theory (Vogt, 2008) and expectancy-value theory (Li, et al., 2008). That is not to say that motivational frameworks are the *only* applicable frameworks for studying persistence but are examples of *potentially applicable* frameworks.

From a motivational perspective, choosing to enter and persist in earning an engineering degree can be considered an achievement-related activity because it requires demonstrating competence and meeting standards of excellence. Framed in Eccles' (1983) expectancy-value theory, choosing to engage in earning an engineering degree (persisting in engineering) involves an individual's beliefs both about his or her ability to be an engineer and about how important it is to him or her to become an engineer. As previously mentioned, this theory has a research history within educational psychology related to occupational choices. This history demonstrates the potential usefulness of this model for examining persistence in earning an engineering degree.

A Practical Example

Details of the Study

This study addressed the primary research question: How do students' beliefs about being engineers in the future shape their achievement-related choice to pursue engineering? The study examined engineering students' perceptions of themselves as future engineers, their achievement-motivation beliefs in pursuing engineering, and how these perceptions and beliefs changed from the first to the fourth year of college. This study was part of a larger body of work, the Academic Pathways Study (APS), conducted by the Center for Advancement of Engineering Education (CAEE) (Clark, et al., 2008; Sheppard, et al., 2004).

In conjunction with expectancy-value theory, this study used multiple case study research methods. The study is both qualitative and longitudinal using semi-structured interviews collected over a four-year period with ten Technical Public Institution (TPub, pseudonym) students being analyzed. Each of the ten participants was interviewed once per year for a total of 40 interviews. Consistent with the case study method, the semi-structured interviews were triangulated with interview and survey data.

Contributions of the Theoretical Framework

In addition to Eccles' expectancy value theory (1983), this study was guided by multicase study methods. As opposed to ethnography and grounded theory, case study methods are particularly appropriate for qualitative studies where the theoretical framework is specified in advance (Yin, 2003). Together these theory and method frameworks shaped our decisions regarding 1) data sources to incorporate, 2) data analysis process, and 3) the interpretation of results, as illustrated through the specific examples given in the following sections.

Choice of Data Sources

Consistent with the tenets of social cognitive theories, Eccles' (1983) model is based on an individual's own *perception* of his or her abilities and task values that shape engagement and persistence behavior; it is not his or her *actual* ability or task completion that is important. Consequently, all data used in the analysis is self-report data.

Approach to Data Analysis

We used Miles and Huberman's (1994) analysis approach, with additional supplemental references (Patton, 2002; Stake, 2006; Yin, 2003), to examine each case separately before examining the set as a whole using a combination of inductive and a priori coding. The first passes through the data involved inductive coding with expectancy-value theory in mind. For subsequent passes, these codes were refined and combined with a priori codes developed from expectancy-value theory. For example, Eccles (2007a) defines four categories of subjective task values including interest, importance, utility and cost. Starting with the literature definitions, operationalized definitions were developed through the inductive analysis. These value constructs are shown in Table 1 along with the literature and operationalized definitions. In this way, the analysis is grounded in the theoretical framework.

Table 1: Value Codes Showing Definitions and Examples of Use

Primary Code	Sub-Codes	Literature Definition	Operationalized Definition	Example
Value	Attainment	The perceived importance of doing well on a task, particularly to how engaging in the task is consistent with self-concept	A reason for pursuing (or not pursuing) engineering or other career related to being the type of person who does that career	Being and engineering-type person
	Cost	The price of success or failure in terms of effort, time and/or psychological impacts	The price of success or failure in terms of effort, time and/or psychological impacts of pursuing engineering or another career	Being an engineer means not being able to pursue interests in art
	Interest	The enjoyment experienced in doing the task	The enjoyment (or lack of enjoyment) experienced in doing engineering activities and/or being or becoming an engineer in the future	Engineering is the career name for the hobbies I enjoy
	Utility	The perceived future direct or indirect importance of engaging in the task	The perceived usefulness (or lack of usefulness) of being or becoming an engineer and/or earning and engineering degree	Engineers are well-paid

Interpretation of Results

Simplifying the results, we answered the overarching research question "How do students' beliefs about being engineers in the future shape their achievement-related choice to pursue engineering?" by demonstrating that students' self-perceptions as future engineers are connected to both competence and value beliefs and to the choice to persist in engineering. Specifically, the results showed: a) even in their fourth undergraduate year, three out of ten participants were uncertain about themselves as future engineers; b) students choosing to pursue an engineering degree because they identify with the types of activities in which engineers engage, experience the persistence choice process differently than students who choose engineering for other reasons; and c) all students ultimately had positive competence beliefs, although two women participants continually renegotiated definitions of competence in engineering.

More importantly, interpreted in light of motivational theory, these findings make three significant contributions to advancing motivational research. First, looking at persistence as a longitudinal process and observing how competence beliefs change over time provides insight into separating self-concept of ability and expectancies of success which are two theoretical constructs that have been reported as difficult to separate in previously in existing research (Eccles & Wigfield, 1995; Eccles, Wigfield, Harold, & Blumenfeld, 1993; Watt, 2008; Wigfield, 1994; Wigfield & Eccles, 2000). Second, by coding and grouping themes about engineering students' self-perceptions as future engineers, this research operationalizes engineering identity into categories that could lead to quantitative instruments and measures for predictive and correlational studies within the expectancy-

value model. Third, this research extends existing educational psychology findings related to the development of competence, value and identity beliefs beyond high school and through college.

Discussion

The purpose of this paper is to highlight the value of motivational frameworks in engineering education research by 1) introducing the rich history of motivational research within the field of educational psychology, 2) showing how research in engineering can connect to and expand this rich research heritage using an example from current engineering education research. This first goal was accomplished through the brief introductions to three motivational frameworks including self-efficacy, self-determination theory and expectancy-value theory. A sample of research results from educational psychology was presented along with connections to existing and potential engineering education research needs. The second purpose was accomplished through a case-study example demonstrating how use of Eccles' expectancy-value theory contributed to data collection, analysis and interpretation decisions in a persistence study.

As stated in the introduction of this paper, "motivation" is a topic that is frequently mentioned in engineering education papers. However, very few of these papers provided theoretical frameworks to focus their studies or explain research results. Engineering faculty learning to conduct rigorous engineering education research often find that understanding theoretical frameworks is a conceptual "hurdle" which stands in the way of their development as researchers (Borrego, 2007a). So presenting theoretical frameworks for an important topic like "motivation" contributes significantly to the engineering education research community.

This paper also provides engineering educators with frameworks to understand how students make the choice to stay or leave engineering. We see that retention choices are affected by a variety of factors, and may be frequently renegotiated. This work suggests that educators can support retention in engineering by helping students see the utility and value of classroom activities, and of engineering as a field. Educators also play an important role in enhancing students' image of themselves as competent future engineers.

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Acknowledgements

The Academic Pathways Study (APS) is supported by the National Science Foundation under Grant No. ESI-0227558 which funds the Center for the Advancement of Engineering Education (CAEE). CAEE is a collaboration of five partner universities.

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