AC 2012-3761: CAPSTONE DESIGN FACULTY MOTIVATION: MOTIVATIONAL FACTORS FOR TEACHING THE CAPSTONE DESIGN COURSE AND MOTIVATIONAL INFLUENCES ON TEACHING APPROACHES

Cory A. Hixson, Virginia Tech

Cory A. Hixson is a graduate student in engineering education at Virginia Tech. Previous experience is in audio/visual engineering and K-12 math/science education. His research interests are in faculty motivation, entrepreneurship, design education, K-12 engineering/STEM education, and research to practice in engineering education

Dr. Marie C. Paretti, Virginia Tech

Marie C. Paretti is an Associate Professor of engineering education at Virginia Tech, where she co-directs the Virginia Tech Engineering Communications Center (VTECC). Her research focuses on communication in engineering design, interdisciplinary communication, and collaboration, and design education. She was awarded a CAREER grant from NSF to study expert teaching practices in capstone design courses nationwide and is Co-PI on several NSF grants to explore identity and interdisciplinary collaboration in engineering design.

Mr. James J. Pembridge, Virginia Tech

Capstone Design Faculty Motivation: Motivational Factors for Teaching the Capstone Design Course and Motivational Influences on Teaching Approaches

Abstract

What motivates the design educator during course planning and implementation? What are the faculty motivational influences at play in the capstone design course? Are there existing motivational constructs that can be applied to design education? In this study, interviews with engineering design faculty members were analyzed to explore if and how subjective task value constructs – attainment values, intrinsic values, utility values, and relative cost – can be applied to design faculty motivation to implement (or avoid) certain pedagogies during the capstone design course. This study broadens the use of expectancy-value theory and establishes its potential for use in design education motivation research. The findings represent a starting point in the discussion of motivation in design education as it pertains to capstone design faculty.

Introduction

Capstone design faculty demonstrate an engagement with students not commonly found in more traditional university lecture courses. This engagement emerges in the form of coaching, protecting, role modeling, and other mentoring functions, as supported by a 2009 national survey of capstone design faculty and follow-up interviews with over forty capstone faculty^{1,2}. The mentoring functions, course structure, and course facilitation typically require capstone faculty to devote additional time, cognitive resources, and energy to planning and implementing the capstone design course. The high time investment typically required both to learn new teaching approaches that differ markedly from familiar models and to effectively mentor teams, coupled with an often-marginalized role for capstone courses in the curriculum, raise questions regarding faculty motivation. Why, that is, do faculty choose to pursue this type of teaching, and how do they make teaching decisions within the course? These questions become more critical as calls for increasing emphasis on professional practice within the curriculum continue to grow³. Understanding the motivational factors that promote or deter choosing to teach a capstone design course and implementing specific pedagogical approaches is critical in supporting the design education community as we seek to develop new design educators and provide ongoing support for current faculty. Such understanding could help support existing capstone design faculty members' growth in expertise, create relevant professional development resources, and encourage new faculty members/university departments to implement capstone design courses. It can also provide course coordinators with strategies for engaging project and industry advisors and for positioning the role of practice-oriented courses across the curriculum.

However, little if any work to date explores faculty motivation with respect to design education. To address this gap, this paper analyzes secondary interviews conducted with capstone design faculty; the interviews focus specifically on teaching practices, and thus do not necessarily address faculty motivation broadly. They do, however, provide meaningful insights into why faculty implement (or avoid) certain teaching approaches in capstone design courses. The interviews are part of a larger study of capstone education that seeks to better understand effective teaching in this domain that includes a national survey (Phase 1), interviews with a stratified subsample of survey participants (Phase 2) and case studies of a subsample of interview

participants (Phase 3) ⁴. Data for this analysis is drawn from Phase 2. Because little is known about faculty motivation with respect to design education, we begin by focusing on a single field; industrial, systems, and manufacturing engineering was selected as the focal point because the field has a strong history of capstone courses and is widely represented across institutions. Subsequent analysis will follow for all major engineering fields.

The interviews for analysis include faculty from Industrial and System Engineering departments at a variety of institution types and experience levels. Through detailed analysis of interviews this paper aims to reveal emerging motivational themes held by capstone design faculty. The analysis is guided by existing motivational frameworks, and also identifies emergent themes grounded in the data. Candidate theories for considering faculty motivation in the design community arise from multiple disciplines and sub disciplines. Theories considered in this study were first developed and tested in fields such as general education, educational psychology, student motivation, teacher motivation, cognitive science, and the general teaching and learning sciences. Candidate motivation theories include, but were not limited to, expectancy-value theory ⁵; achievement goal theory ⁶; a model developed by Abrami et al. ⁷; and potentially the integration of multiple existing theories. As noted above, little if any prior research exists applying established motivational theories to design education faculty, leaving a gap in the engineering education literature that this study intends to address. The findings of this study represent a starting point in the discussion of motivation in design education as it pertains to capstone design faculty.

Literature Review

As briefly mentioned above, a variety of motivational theories exist in the literature. Although many of these theories have been extensively applied to student learning, the application of motivational theories to teacher motivation is more limited and often focuses on the strength of a teacher's motivation not understanding its causes ⁶. Butler also suggests that the lack of a general theory framing the motivation of student teachers' goals is a potential reason for the scarcity of conceptual frameworks and measures guiding further research on teacher motivation ⁶. Although limited, the application of motivational theories to general teacher motivation is growing. Recent studies have applied motivational frameworks to address teachers' use (or non-use) of cooperative learning ⁷. In this study, Abrami and colleagues developed an instrument to address teachers' implementation (or avoidance) of cooperative learning. The underlying motivational theories in consideration were the expectancies, values, and costs of implementing cooperative learning. Another study of teacher motivation discusses the limitations of applying a single motivational theory to teacher motivation and thus, presents a model that integrates multiple motivational theories and frameworks. This study by Neves de Jesus and Lens integrates expectancy-value theory, goal value theory, self-efficacy theory, intrinsic motivation, and the learned helplessness model into the comprehensive "cognitive-motivational" model ⁸.

Butler further develops the extension of motivational theory to teacher motivation with achievement goal theory. This theory, as Butler applies to teachers, is comprised of four achievement goal factors: ⁶, p. 242

“(a) learn, develop, and acquire professional understandings and skills (mastery orientation);

- (b) demonstrate superior teaching ability (ability approach);
- (c) avoid the demonstration of inferior teaching ability (ability avoidance); and
- (d) get through the day with little effort (work avoidance)”

Achievement goal theory has been used in multiple studies connected to teachers’ instructional practices and has shown promise as a teacher motivation theory for shedding light onto teacher motivation to use educational innovations ^{9, 10}.

A final candidate theory for capstone design faculty motivation is Eccles et al. expectancy-value theory. Eccles et al. expectancy-value model was originally developed in 1983 ¹¹ and has undergone numerous revisions since entering the literature. The model relates an individual’s expectancy-related and task-value beliefs to their achievement performance, persistence, and choice and has been shown to provide insight on a range of topics such as academic motivation, sports motivation, and career choice ⁵. Specifically, the Eccles et al. model considers probability of success and relative value as key factors of choice. Another important characteristic of this model is its social cognitive considerations, such as perceptions of others’ attitudes, others’ expectations, and the individual’s thoughts on previous personal achievement experiences. Expectancies are defined as “individual’s beliefs about how well they will do on upcoming task, either in the immediate or longer-term future” ^{5, p. 119}. Eccles & Wigfield also detail four components of subjective task value ^{5, p. 119}:

“attainment value: the personal importance of doing well on the task

intrinsic value: the enjoyment the individual gets from performing the activity or the subjective interest the individual has in the subject

utility value: how well a task relates to current and future goals, such as career goals

relative cost: how doing one activity interferes with doing other possible activities”

The following is visual representation (Figure A) of the Eccles et al. expectancy-value model of achievement.

Figure 1. 2010 Eccles et al. Model of Achievement-Related Choices (Eccles [Parsons] et al., 1983)

Figure A

Eccles et al. comprehensive expectancy-value model w/ original caption¹²

While no sources have been found that directly relate the Eccles et al. model to teacher motivation, this model has been successfully used in a variety of settings, has been applied to student motivation and achievement, and Neves de Jesus and Lens include it in their integrated model for teacher motivation⁸. As a result, the Eccles et al. model has theoretical promise for enhancing our understanding of faculty motivation in design education and the capstone course. Certainly there are other motivational frameworks that have not been considered in the current literature review, such as intrinsic motivational theories, goal theories, control theories, etc. These motivational frameworks have been omitted primarily due to their paucity in the existing teacher motivation literature. In addition, as noted below, an analysis of capstone faculty interviews shows strong support for the explanatory power of expectancy-value theory in this context.

Research Questions

As noted earlier, the nature of the capstone design course requires faculty members to invest more time and energy, as well as use different pedagogical approaches, such as course structure, mentoring, coaching, and advising. These characteristics are less commonly required in courses outside of the capstone design experience. The capstone course also represents a key transitional period in a student's academic and professional development. The course commonly occurs later

in the student's academic career and is intended to develop and demonstrate student's current and future capabilities as a professional. The capstone course can also be viewed as a challenging course for students, as it requires synthesis of prior knowledge, the development of professional skills, and often a significant time commitment. These factors make it important for the design education community to understand the underlying motivational concepts faculty experience in relation to the capstone course. To this end, the research presented seeks to answer the following research question.

What, if any, motivational theories can be applied to understanding capstone faculty's decision to implement or not implement specific pedagogical approaches in the capstone course?

Methods

This study represents an exploratory qualitative study of secondary transcripts obtained from a larger study that consists of a 2009 national survey of capstone design faculty and follow-up interviews with over forty capstone faculty in various engineering departments, institution types, and geographic locations^{4, 13}. An exploratory study was chosen due to the limited application of existing motivation frameworks to capstone design faculty members. The exploratory nature of the study allowed for emergent themes to appear in the data, informing both the analysis and overall discussion of motivation in design education.

Using secondary interview data that was collected to study expertise in capstone design required the researcher to initially read the interviews and determine what, if any, themes emerged from the data. A subset of six Industrial and Systems Engineering (ISE) interviews were chosen to establish a starting point and baseline for analysis and future study. These interviews represent ISE faculty from various demographics, institutions, geographic locations, and course structures. After initially reading the interviews informed by an understanding of the motivation theories described above, it was determined that there were themes related to Eccles et al. subjective task value. More specifically, the subjective task value portion of the expectancy-value model was chosen because there appeared to be convergent themes between the interview data and the four components of subjective task value. The interviews were then coded through content analysis, using subjective task value constructs to determine which motivational values ISE capstone design faculty members expressed during their interviews. Content analysis was chosen because it allows the potential to employ *a priori* coding using existing motivational frameworks¹⁴. Table 1 in Appendix A details the construct, operating definition, and an example of the corresponding data found in the interview transcripts.

Results and Discussion

As noted, the existing interviews provide insights into what motivates teaching decisions within the capstone course, and a preliminary analysis suggests that subjective task value, as a component of expectancy-value theory, offers a useful lens for understanding this motivation. The remainder of this section describes the four subjective task value categories as they appeared in the data.

The interview data analysis revealed 135 instances of one of the four subjective task value

constructs presented by Eccles et al. Of the 135 coded instances, approximately 12% related to attainment values (n=16), 6% related to intrinsic values (n=8), 65% related to utility values (n=88), and 17% related to relative cost (n=23). From this breakdown, the subjective task values held by ISE capstone design faculty refer mainly to utility values with all other subjective task value constructs holding significantly less weight.

Utility Values

Utility values, as described by Eccles et al., represent “how well a task relates to current and future goals, such as career goals.”^{5, p. 119} It is interesting to note that in the interviews the vast majority of the utility value references related to current and future goals of the students more so than the faculty. Many of the faculty mentioned that they performed tasks, directed groups, or structure their courses based on current or future goals for their students. These goals included communication and professional skills, teamwork, understanding the difference between the real world and academia, appropriately defining problems, and perseverance when presented with a difficult task. The following is an example of one informant's utility values directing their capstone teaching approach, specifically as it pertains the student goal of defining problems:

...once the students pick up the projects they are the ones that have to detail what the problems are verses me telling them. What are the details of the problems? Because that's part of that discovery; talking to clients and visiting client sites; learning what the problems are on their own. That becomes kind of a part of their discovery. They can do a much better job verses if you throw all the problems at them and say, ok, go ahead and now handle these problems. So this is another thing that works very good, is to have the students detail the problems.

This emphasis on utility value as it pertains to student careers is significant not only in what it illuminates about capstone faculty, but in its contrast to anecdotal evidence regarding the emphasis on “delivering the content” in many traditional courses. Content delivery – making sure students learn statics or thermodynamics or transport phenomena – has only an indirect relationship to professional practices; that is, the mastery of the content is somewhat removed from the ability to apply that content within professional work, and not all technical content (even “core” content) is relevant to all positions students may take upon graduation. The utility value these capstone faculty address, however, is linked directly to job experiences and expectations that most (if not all) students will encounter in post-graduation work.

It is important to note that other utility factors also played into faculty decisions, including meeting goals set by outside companies, being fair to students/team members, student interest/buy-in, and meeting ABET standards. The following is an example of how such extrinsic factors modified the capstone course at one institution:

We had a fairly difficult period about 6 or 8 years ago when we had students going through selecting an outside project and finding a company they can work in and coming up with a project that would meet our objectives. We had a difficult time getting, kind of the projects, sort of designed to meet the goals of the ABET specifications for the design project, which was that it's supposed to be comprehensive across the curriculum. It was supposed to involve people in a variety

of different kinds of studies and analyses. So basically when we moved away from that we moved forward a highly structured set of requirements that essentially became the outline of the project report. And we let that be the guide for what the students were expected to produce.

Relative Cost

The second most prevalent subjective task value determining how capstone faculty approach the capstone course was relative cost (17%). Eccles et al. describe relative cost as “how doing one activity interferes with doing other possible activities.”^{5, p. 119} Faculty mentioned that they would have to consider time when determining problem complexity, sacrificing complexity/real world characteristics for a problem that is manageable in one or two semesters. They also mentioned that at times they were forced to intervene with team or project problems due to the limited length of the course, despite wanting to give the students time to handle it on their own. Below is one such example where a faculty member discusses when to intervene in order to get higher quality results from their students.

So I'm balancing this line where the students are capable of doing something... It's unusual that they don't, but if they're not producing, and I have to decide when do I step in and say, "all right, you know you need to do something for this company, you owe it to them and owe it to yourself."

Attainment Values

Thirdly, attainment values comprised of 12% of the coded subjective task values. Eccles et al. describe attainment value as "the personal importance of doing well on the task."^{5, p. 119} As opposed to utility values where faculties' actions were directed by students' goals, attainment values remained personal to the faculty member. Attainment values found in the data included areas such as successfully advising teaming issues, technical competencies, fairness in assigning students' grades, and the relationships held with outside companies. Of particular relevance is the notion that faculty expressed the importance of succeeding at helping students avoid failure.

There were various ways of stepping in but the majority of it was just sitting down and talking with them. I sat down and talked with them as a group on most occasions. I hold individuals out and talk to individuals about their own personal problems on the locations. It's you know the old – you lead a horse to water but you can't make him drink... Sometimes we get back and, you know, *I used to beat myself up over that*. The older I get the more I realized that that's just going to happen. (emphasis added)

Intrinsic Value

Finally, faculty expressed intrinsic value (6%) in relation to their experiences with the capstone course. Eccles et al. describes intrinsic values as "the enjoyment the individual gets from performing the activity or the subjective interest the individual has in the subject."^{5, p. 119} Intrinsic values showed up as faculty members expressing interest or enjoyment with a particular component, task, assignment, or objective of the capstone design course. Below is an example

of one faculty member describing their enjoyment and interest in solving problems, making the class relevant to the real world, and having fun.

So I think that making the class as 'real world' as possible, cliché as that is I know, is our primary job as instructors. On the flip side, I also think it's fun. As an engineer, I love to solve problems. That's what gets me up in the morning, and I think there's room for that fun and enjoying what you're doing. And so, I try to bring that to the classroom as well. And helping students understand that they can enjoy what they're doing. And... and... lighten up a little bit, if you will, but at the same time be very intense about generating value for the companies that they're serving.

For at least a subset of faculty, then, teaching the capstone course allows them to engage in the parts of engineering that they themselves enjoy, and to transmit that enjoyment to students. Student design projects thus perhaps serve as a kind of proxy for faculty's own engineering work in a way that more traditional content-delivery courses may not.

Intrinsic values also emerged through the language used by faculty. In many interviews faculty spoke about teaming issues, project goals, and interactions with companies using a first person term, such as "we", instead of a third person, such as "they". This subtle and underlying inclusion of oneself as a part of an activity potentially speaks to the deep-seated nature with which faculty relate to the course. This analysis supports further research in order to explore how intrinsic values and identity relate to faculty members' pedagogical approach to the capstone course.

Conclusions and Future Work

Although the interviews analyzed in this study were not initially intended to reveal information on faculty motivation in the capstone design course, this study represent a starting place for faculty motivation in both the design community and engineering education. Specifically, this study shows promise that the subjective task value constructs from Eccles et al. motivation framework are present as motivational values for ISE capstone design faculty, especially utility value. Perhaps most importantly, the analysis points to strong connections among faculty members' motivation, their understanding of engineering work, and (as suggested by intrinsic value) their own connection to the practice of engineering. While much more work is needed to substantiate and understand these connections better, they point to factors that may play a significant role in both supporting current faculty and developing new design educators. This work also shows the promise of Eccles et al. expectancy-value model as a starting place for further understanding capstone and design education faculty teaching motivation.

While the results here are promising, this study does have limitations that point to the need for significant additional work. First, the interviews analyzed were limited to faculty members who taught their capstone course in the Industrial and Systems Engineering discipline. Further analysis of faculty interviews would serve to expand the body of motivational knowledge beyond the ISE capstone faculty. Also, further research will inform if other disciplines place equivalent importance on utility value or if there are more appropriate subjective task values for other disciplines. Continued research applying motivational frameworks to design education and the

capstone design course could also solidify the use of expectancy-value motivation theory or present new motivation theories that address design education faculty motivation.

Finally, this study was an exploratory study, and as such, did not attempt to obtain an in-depth understanding as to why faculty value aspects of the capstone course expressed in the interviews. The intention of this study was to determine which motivation theories could potentially be applied to capstone design faculty and subsequently which, if any, subjective task value categories were present in preexisting faculty interviews. Further research specifically targeting capstone faculty motivation will serve to address the explanatory nature answering questions such as; Why do faculty express certain motivation values? and What motivates faculty to teach the capstone design course? Addressing such questions can help the capstone community develop its most critical resource: dynamic, engaged teachers.

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Appendix A

Table 1: Construct, definition, and data example used during the coding process of secondary capstone faculty interviews.

Construct	Definition - 5	Example in Interview Data
Attainment Value	<ul style="list-style-type: none"> the personal importance of doing well on the task linked to the relevance of engaging in a task for confirming or disconfirming salient aspects of one's self-schema (i.e., because tasks provide the opportunity to demonstrate aspects of one's actual or ideal self-schema, such as competence in various domains, tasks will have higher attainment value to the extent that they allow the individual to confirm salient aspects of these self-schemata) 	<p>"So with that particular group I did reach a point where, I'm saying the very fine line between serving the students who are my customers as well as serving the industries that are my customers, what I don't want to do is have an industry partners say, 'Wow that was horrible. That was a terrible experience. Her students are incapable and we didn't get anything out that.'"</p> <p>"Because it's important to me that the team I am on be successful, and I don't intend to not be successful just because I have team member that's not going to be helpful. So I have conversations like that with teams at least once a semester where somebody isn't pulling their weight..."</p>
Intrinsic Value (Interest-enjoyment)	<ul style="list-style-type: none"> the enjoyment the individual gets from performing the activity or the subjective interest the individual has in the subject 	<p>" I think that's an important part to kind of broaden their education and see how different people approach different problems with different tools, different approaches"</p>
Utility Value	<ul style="list-style-type: none"> determined by how well a task relates to current and future goals, such as career goals can have positive value to a person because it facilitates important future goals, even if he or she is not interested in the task for its own sake captures the more "extrinsic" reasons for engaging in a task relates directly to an individual's internalized short- and long-term goals 	<p>"... I say, the two objectives, of course, are to help the client resolve a real-world problem and to provide a good learning experience for the student."</p>
Relative Cost	<ul style="list-style-type: none"> conceptualized in terms of the negative aspects of engaging in the task, such as performance anxiety and fear of both failure and success, as well as the amount of effort needed to succeed and the lost opportunities that result from making one choice rather than another 	<p>" Well, the things that don't help is to tell the students exactly what to do if you are dealing with capstone year, ok? Because basically you demoralize them because they are seniors. They are very bright. They are capable. They can do. But if you try to do too much hand-holding and tell them step by step what to do their final result is not as good as if you give them autonomy at that time of the year and let them work on the project."</p>