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Work in Progress: A Longitudinal Study of Student Motivation Throughout the Lifetime of a First-Year Course

Sarah Anne Blackowski, Virginia Tech

Sarah is a PhD student in the Department of Engineering Education at Virginia Tech. She has a bachelor's degree in Aerospace Engineering from Embry-Riddle Aeronautical University and, during that time, spent a summer at Franklin W. Olin College of Engineering for an REU in engineering education. Sarah's research interests include: motivation, student and faculty metacognition, and engineering faculty self-regulated learning.

Dr. Holly M. Matusovich, Virginia Tech

Dr. Matusovich is an Associate Professor in Virginia Tech's Department of Engineering Education. She has her doctorate in Engineering Education and her strengths include qualitative and mixed methods research study design and implementation. She is/was PI/Co-PI on 10 funded research projects including a CAREER grant. She has won several Virginia Tech awards including a Dean's Award for Outstanding New Faculty. Her research expertise includes using motivation and related frameworks to study student engagement in learning, recruitment and retention in engineering programs and careers, faculty teaching practices and intersections of motivation and learning strategies.

Prof. Tamara Knott, Virginia Tech

Tamara Knott is Associate Professor of Engineering Education at Virginia Tech. She primarily teaches Engineering Foundations classes to first year engineering students. Her interests include assessment and pedagogy. Within ASEE, she is a member of the First-year Programs Division, the Women in Engineering Division, the Educational Research and Methods Division, and the Design in Engineering Education Division. She is also a member of the Society of Women Engineers (SWE) and is the Faculty Adviser for SWE at VT.

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Introduction

There are a wide variety of approaches to curricula in the first-year in engineering [1]. Some institutions admit students directly to their engineering discipline or major. Others focus on a general engineering curriculum before students select their engineering discipline or major [2]. Research shows that engineering programs that require students participate in First-Year Engineering (FYE) programs have greater retention for engineering [3]. FYE programs provide students opportunities to engage in mastery experiences related to engineering before committing to a specific engineering discipline. Participating in the mastery experiences provided through the FYE program should contribute to student motivation to persist in engineering. This work will take a look at one FYE program (two courses) and student motivation across multiple years.

Motivation is a foundational aspect of a students' academic development. Students who are intrinsically motivated naturally lean toward academic achievement [4]. This means that students will seek their short or long-term educational goals, depending on each student's definition of academic achievement. Students can also be motivated extrinsically through the use of rewards or praise [5]. Either way, understanding motivation can be useful to students and instructors alike. There is little work comparing which types of FYE courses and instruction modes are the most motivating to their students [6-8]. Many engineering programs have implemented the FYE program in different ways. One way to affect how the course changes is to give faculty and instructors autonomy over their course. The main purpose of this study is to understand how faculty autonomy affects student motivation in a FYE program. The research question is: *With changes in instructor autonomy, how does student motivation change in a First-Year Engineering course?*

We addressed this research question using existing data from three and a half years of FYE program surveys. The surveys used were implemented to collect student feedback on the quality of the course as well as gain an understanding of student identity and motivation. For the purposes of this paper, we will only discuss the student motivation aspects. This study provides meaningful information about the nature of student motivation through the varied implementations of instructor autonomy. Engineering programs could leverage these findings to make decisions about how an FYE should be implemented to maximize student academic motivation by also considering faculty motivation.

Literature Review

Engineering students in the FYE program

For students, choosing an appropriate major is a critical factor in ensuring a productive and successful college experience. Major choice determines the nature of work students engage in and the faculty and peers they come in contact with. For engineering students, the selection of a discipline can be difficult. The FYE course has proliferated in U.S. engineering programs, with nearly 60% of these programs touting a course of their own [9]. Many first-year students take a FYE course which provides them with engineering design, global interest, math skills, academic success, engineering profession, latent curricular and professional skills, communication skills, and skill with engineering specific tools [1, 3]. With the engineering context knowledge gained from the FYE course, students are better prepared to declare an appropriate engineering major.

Orr et. al [2] analyzed longitudinal data from ten U.S. institutions to determine outcomes of different matriculation pathways into engineering. The two most prevalent matriculation pathways were Direct Matriculation (DM) to a specific major and FYE programs. FYE programs were found to promote persistence within engineering as a whole and also seem to be more successful in preparing students to make informed major choices. FYE programs also have the quickest path to graduation in engineering, which may be a result of fewer FYE students changing their majors as every change of discipline within engineering requires an average of two additional semesters [10]. Some FYE programs have established common introductory engineering courses which aim to increase retention, provide students with design experience, improve teamwork skills, and increase success rates for students with nontraditional backgrounds [11]. This is the context of our study, which will be discussed in detail later in this paper. Another advantage of a common FYE program is that it can provide access to a wide array of engineering experiences to assist students with choosing an intended major [1]. The common first-year experience provides students with a place to explore and address their misconceptions about the engineering profession and its disciplines, a setting which student motivations become tangled with those of the department and faculty.

MUSIC model of academic motivation

Motivation theories attempt to explain the relationships between beliefs, values, and goals with respect to action. A number of motivational theories are related to the student themselves such as Self-Determination Theory [5], Expectancy-Value Theory [12, 13] or Self-Efficacy [14]. In this study, the MUSIC model of academic motivation [4] was used to measure student motivation in the FYE courses. The MUSIC model was chosen because there are valid and reliable forms of assessing the MUSIC model components in a college course, which made it a powerful tool in this FYE program.

Academic motivation is important because motivated students tend to engage in activities that promote learning and achievement in a learning setting [15]. Understanding student academic motivation throughout the FYE program is valuable to the continuing improvement of these programs. The five components of the MUSIC model are that students are motivated when they perceive that (1) they are empowered, (2) the content is useful, (3) they can be successful, (4) they are interested, and (5) they feel cared for by others in the learning environment. Thus, the MUSIC model inventory measures student perceptions of eMpowerment, Usefulness, Success, Interest, and Caring. This model can be used for both assessment purposes and to inform course design [4].

Study Context

This study was conducted at a large, land grant institution in the mid-Atlantic region of the United States. Engineering students are initially enrolled in the General Engineering program where they take two semesters of First-Year Engineering courses as part of their general engineering credits. These courses focus on teamwork, technical and professional communication, implementing engineering tools, engineering design, and exploring engineering as a career. Important to note for this study, the department responsible for hosting the course changes the course and its relation to its instructors. Course 1 and Course 2 are offered in sequence with one another. Course 1 (offered in the Fall academic term) introduces foundational concepts in engineering such as: defining problems, working in teams, and beginning to explore engineering tools (MATLAB, etc). Course 2 (offered in the Spring academic term) builds on the skills from Course 1 by applying them in increasingly more ill-structured problems. Data collection for this analysis.

In recent years, the course has changed with regard to the degree of centralized Departmental control and one of the changes considered in this analysis is the level of autonomy the instructor had over the course content and delivery. Table 1 shows each year with a label and their autonomy level.

Table 1: Level of autonomy for each academic year

Academic Year	**Level of Autonomy for Instructors**
2015-16	Most structured
2016-17	Most Autonomous
2017-18	Autonomous with assigned teams
2018-19	Autonomous with structure

The FYE program in this study is well established and has been a strength of the engineering program at the institution for decades. In 2013 the FYE courses underwent a revision with the goal of moving away from skills based instruction to a focus on doing engineering. Another goal of the curriculum revision was to move away from courses taught with common slides, assignments and tests, to allow individual instructors more autonomy in how courses objectives are met and yet maintain the “common” nature of the courses.

In the first year following the revision, instructors, which included both faculty and graduate students, were asked to use a common set of slides and assignments so that the instructors could experience the courses as intended in the redesigned. This study covers the next three and a half academic cycles of the courses during which the level of instructor control over specific content and assessment methods moved from structured to autonomous and back to autonomous with structure. In 2015-16 instructors used common slides, assignments and assessment and met weekly to discuss the course content. In 2016-17 instructors had full autonomy to meet the learning outcomes of the course. Some instructors worked in instructional teams, which included a mix of new and experienced instructors some of whom were faculty, some graduate students. Some teams chose to use common course materials which they developed as a team while in other teams, instructors met occasionally to share ideas and materials but each largely developed or chose their own materials. In 2017-18 the department returned to a more coordinated instructional approach in which instructors were assigned to work in teams and there were some common assessment across all instructors. In addition to team meetings, held as frequently as the individual team desired, monthly course colloquia meetings for all course instructors were held. The 2018-19 cycle has not yet finished both courses but the department was specific in their use of the slogan “autonomy with consistency” in Fall 2018. We have still labeled it “autonomous with structure” because the course structure was still the same as 2017-18.

Methods

To answer the research question, we utilized existing survey data collected over a three and a half-year period for a non-experimental longitudinal design [16] to explore relationships between incoming student motivation and the course set-up (instructor autonomy).

Participants and Data Collection

All first-year and transfer students are admitted to a General Engineering program at this institution. After completing the first-year curriculum, students are eligible to declare an engineering major. Surveys were administered to the general engineering students at the beginning and end of their first semester and again at the end of their second semester. This study includes data collected since 2015 when the survey was last updated. Survey items collect information about respondents' utility, expectancy, and MUSIC model of academic motivation. In this paper we only discuss the results of the MUSIC model of academic motivation.

All students enrolled in the first-year courses were invited to take the survey. Table 2 shows the total number of consented survey participants. On average, the total number of students enrolled in Course 1 is 1400 students. There are known systematic non-response biases so we believe the sample is representative of the population.

Table 2: Number of consented survey respondents for Course 1.

Term	Course 1 Consented Respondents	Total Course 1 Enrollment	Response Rate (%)
Fall 2015	1340	1706	78.5%
Fall 2016	1133	1577	71.8%
Fall 2017	1413	1951	72.4%
Fall 2018	1235	1787	69.1%

Table 3: Number of consented survey respondents for Course 2.

Term	Course 2 Consented Respondents	Total Course 2 Enrollment	Response Rate (%)
Spring 2016	951	1677	56.7%
Spring 2017	959	1472	65.1%
Spring 2018	1263	1868	67.6%

Instrumentation

Each of the following scales included on the first-year survey consists of 4-6 items measured on a 6 point Likert scale (1 – strongly disagree, 6- strongly agree). While the survey contains additional items, we have used only the MUSIC model items from the survey.

MUSIC Model items

Because the MUSIC items pertain to students' experience in the course, they are only included on the surveys offered at the end of the first and second semesters. Students reported their perceptions of each of the MUSIC model components using the MUSIC Model of Academic Motivation Inventory – College Student version [17], which includes five empowerment items, five usefulness items, four success items, six interest items, and six caring items. This inventory has been validated in several studies and has been shown to adequately represent the five-factor structure of the MUSIC model with college students. Items on the survey related to the MUSIC model include “I had opinions in how to achieve the goals in the course” (eMpowerment), “In general the coursework was useful to me” (Usefulness), “I was confident that I could succeed in the coursework” (Success), “The instructional methods used in this course held my attention” (Interest), and “The instructor was willing to assist me if I needed help in the course” (Caring). Table 3 shows the MUSIC model survey instrument used in this survey aligned with its constructs. The FYE survey contains all MUSIC model items in a scrambled order so students will not be able to align factors themselves.

Table 3: MUSIC Model Survey Instrument Constructs

Scales	Items by Scale
Empowerment (5 items, α = 0.91)	• I had control over how I learned the course content. • I had the opportunity to decide for myself how to meet the course goals. • I had the freedom to complete the coursework my own way. • I had options in how to achieve the goals of the course. • I had flexibility in what I was allowed to do in the course.
Usefulness (5 items, α = 0.96)	• In general, the coursework was useful to me. • The coursework was beneficial to me. • I found the coursework to be relevant to my future. • I will be able to use the knowledge I gained in this course. • The knowledge I gained in this course is important to my future.
Success (4 items, α = 0.93)	• I was confident that I could succeed in the coursework. • I felt that I could be successful in meeting the academic challenges in this course. • I was capable of getting a high grade in this course. • Throughout the course, I felt that I could be successful on the coursework.
Interest (6 items, α = 0.95)	• The coursework was interesting to me. • The coursework held my attention. • The instructional methods used in this course held my attention. • I enjoyed the instructional methods used in this course. • The instructional methods engaged me in the course. • I enjoyed completing the coursework.
Caring (6 items, α = 0.93)	• The instructor was available to answer my questions about the coursework. • The instructor was willing to assist me if I needed help in the course. • The instructor cared about how well I did in this course. • The instructor was respectful of me. • The instructor was friendly. • I believe that the instructor cared about my feelings.

Data Analysis
Descriptive statistics were used to explore the research question for this study. An attempt at a bivariate analysis was made by dissecting each course with their means by MUSIC model components.

Preliminary Findings and Discussion
There are 26 items on the MUSIC model survey. For the purposes of showing the effects via the MUSIC constructs, the means of each construct was taken across all of the survey responses. What follows in this section is the descriptive statistics via the bivariate analysis of these motivation constructs.

Bivariate Analysis
In the bivariate analysis, we explored changes in student motivation over the course of the three and a half years. Table 4 shows the means of the MUSIC model constructs throughout the years. At first glance, it is clear that almost every construct has decreased over the course of one year. Between the years, students' MUSIC model scores seem to increase (i.e. from Course 1 F15 to Course 1 F16, from Course 1 F16 to Course 1 F17, etc). This seems to suggest that there could be a slight relationship between instructor autonomy and student motivation, although it is too early in the analysis to make a clear, causal conclusion. It is important to note the drop in means during Fall 2018.

Table 4: Means for each MUSIC construct by each course

	Course 1 F15	**Course 2 S16**	**Course 1 F16**	**Course 2 S17**	**Course 1 F17**	**Course 2 S18**	**Course 1 F18**
eMpowerment	3.99	3.72	4.12	3.83	4.39	4.34	3.24
Usefulness	3.81	3.68	4.03	3.79	4.30	4.26	4.30
Success	4.53	4.37	4.65	4.54	4.87	4.97	3.47
Interest	3.69	3.52	3.91	3.56	4.19	4.08	3.48
Caring	4.78	4.71	4.89	4.72	5.09	5.03	4.91
Autonomy level	**Most structured**		**Most autonomous**		**Autonomous with teams**		**Autonomous with structure**

It is difficult to visualize the data in Table 4, so we constructed Figure 1 to show the steady increase of MUSIC model constructs over time with the exception of Fall 2018.

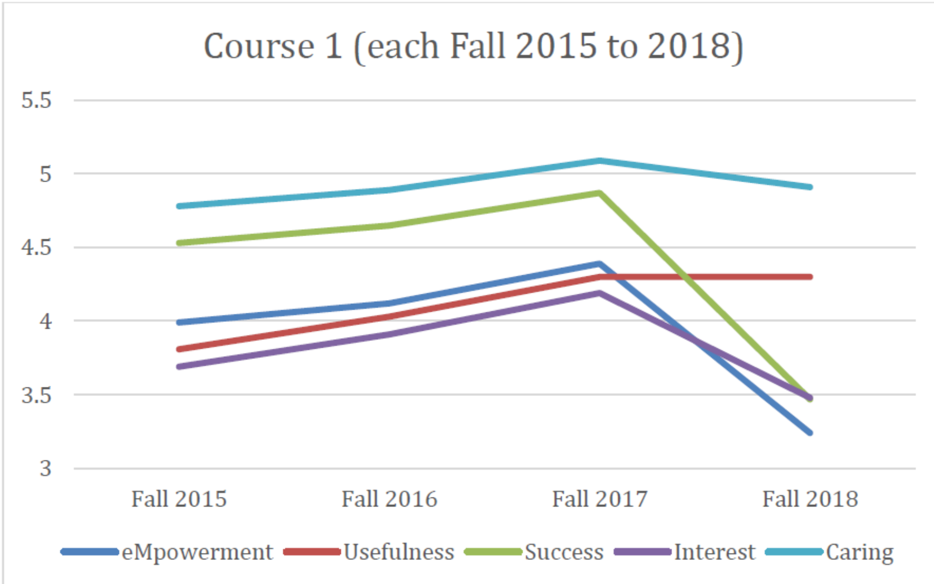

Figure 1: Means for each MUSIC construct for Course 1 (each Fall from 2015 to 2016).

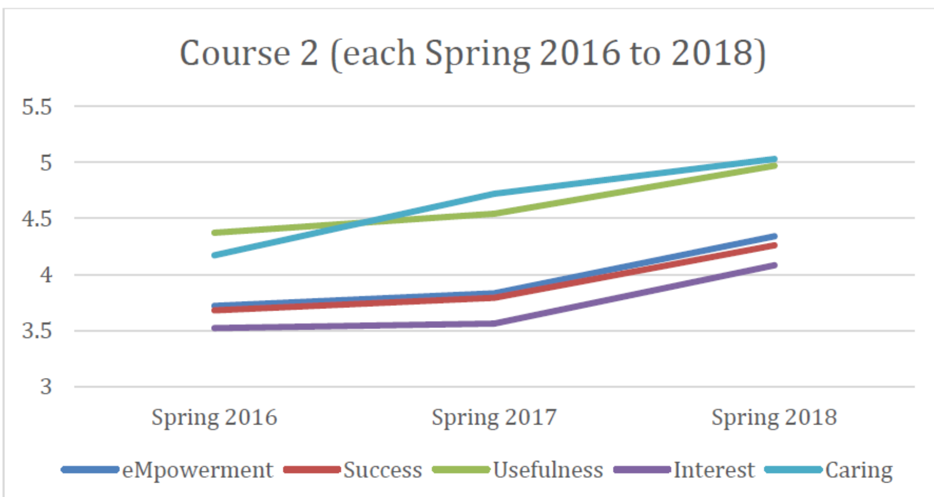

Figure 2: Means for each MUSIC construct for Course 2 (each Spring from 2016 to 2018).

Changes may have been lost upon averaging across all instructors and all students. However, since the ABET self-study reports for engineering departments and other assessments are programmatic. This program-level look at the data is appropriate to understand changes from this perspective. It is also important to consider these preliminary results from a high-level system's perspective. Changes in a system will take a number of cycles to matriculate into the regular rhythm of said system [18, 19]. In this case, we may not be seeing major change because it is not fully integrated into the FYE program in the study context. Additionally, Tolman, Kremling [19] discusses that the student reaction may not always be a result of what a faculty member is doing because there are many constraints on why a student may be motivated.

Implications for Teaching

We believe that one of the factors that influenced student motivation in this study is faculty autonomy. As previously outlined, that nature of faculty autonomy in the context of this particular FYE course varies from academic year to year because of the program's desire for continuous improvement. In terms of recommendations for practice, preliminary findings from this study may support that an autonomy-enabling teacher will facilitate educational and developmental outcomes that are necessary to satisfy a students' psychological needs, thus changing student motivation. Allowing an individual to engage in a learning experience with some level of autonomy will nurture greater mastery, intrinsic motivation, and perceived competence [6, 7]. Ultimately, the motivational styles of an instructor will affect the motivation of a student [5, 8]. Departments that allow faculty autonomy in their courses may be supporting this framework of engaging faculty in the outcomes necessary to satisfy faculty psychological needs, which will then motivate students. More research is needed to investigate this.

A number of new instructors were hired to teach these courses in Fall 2018. Figure 1 shows a decline in student perception of Success, Interest, and eMpowerment during this academic term. It is possible that aspects of these MUSIC components were not feasible due to new faculty teaching the course without previous experience. Jones [4] suggests a number of strategies to address student perceptions of these components, such as: matching assignment difficulty levels to the abilities of the students (Success), giving students control over class activities and assignments (eMpowerment), and present information that challenges students' existing mental models (Interest).

Limitations

The limitations in this study will affect the future work. First, we have no data to discuss the perceived level of course autonomy from the faculty perspective. This would be necessary to make any further statements about the nature of faculty autonomy in this FYE program. Additionally, we have no data to discuss faculty autonomy from the student perspective, which may reveal more information about the nature of faculty autonomy is perceived and how it affects student motivation in the classroom context.

Comparing between years adds more complication to this data because each course and subsequently each year has a new set of students. These differing student populations will affect the patterns in the data. Finally, it is important to note that faculty autonomy is not the single direct factor that will change student motivation in the first year. There are a number of environmental and situational factors that students contend with during their first year. A better understanding of the manifestation of faculty autonomy in the classroom would give more context to the student motivation changes.

Future Work

To address our limitations, we would like to collect data on faculty perceived autonomy as a factor of student motivation by collecting data on faculty perceived autonomy during the course. Given the importance of students' course perceptions the overall course context, steps should be take in future work to obtain student perceptions of faculty autonomy. Additionally, future work will include further analysis of the data to understand which constructs may be affected by these changes in the course by using a Repeated Measures ANOVA across survey results for each year.

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