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AN ANALYSIS OF FIRST YEAR ENGINEERING STUDENTS' COURSE PERCEPTIONS IN TWO INTRODUCTORY ENGINEERING COURSES

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A Comparative Analysis of First-Year Engineering Students' Course Perceptions in two Introductory Engineering Courses

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Abstract - **As a national initiative to support engineering students' retention, engineering programs have seen a wave of revisions in their first-year programs in the last years. These program modifications are intended to enhance student success in engineering, including both students' achievement and students' motivation to persist in an engineering degree. This paper will look at students' perceptions as it compares Traditional versus Revised versions of an introductory engineering course taught in a general first year engineering program. The purpose of this paper is to examine students' course perceptions from two versions of an introductory engineering course. Students' course perceptions are measured using the MUSIC model of motivation. Using a quantitative approach, descriptive comparisons will be analyzed between students' perceptions of the introductory engineering courses. Independent T-tests will be conducted comparing students' perceptions in the two different course types. Motivation constructs included in surveys presented at the end of the semester in the two versions of the course are the measures of students' perceptions used in this study. By measuring students' perceptions using the MUSIC model of motivation, practical implications will be suggested. This information will be especially useful for the instructors and developers of course content and pedagogy.**

Index Terms - Course revisions, Introductory courses, Motivation, Students' perceptions.

INTRODUCTION

Engineering educators usually place a great amount deal of importance and effort on designing pedagogies and instituting new approaches in the classroom. One example is the revision of pedagogical and curricular approaches in first year engineering introductory courses. However, we often have little knowledge about both the results of these revisions and how students perceive these courses. Understanding students' perceptions of the classroom, or even a particular class, is important because, as instructors and researchers, we can improve or adjust teaching and assessment methods, as well as overall activities in the classroom that support academic achievement and students' motivation to learn and/or to persist in engineering. Previous findings suggest that students' course perceptions can affect their motivation to persist in an engineering career [1]. The purpose of this study is to compare students' course perceptions in two versions, 1024 versus 1215, of a required introductory engineering course.

There is a need to understand how to better support students' motivation to learn or to persist in their studies towards an engineering degree. This need is not new; there has been extensive calls about how to better support student retention in engineering programs [2]. Existing research has suggested that student retention can be supported by enhancing not only students' cognitive characteristics, but also students' non-cognitive characteristics, such as motivation to persist in engineering [3]. As a result, engineering colleges have included specific initiatives to not only support students' academic achievement, but also to address students' motivation to learn, and to persist in achieving an engineering degree. As an illustration, engineering colleges have emphasized the "development of motivational first year courses, and student assistance programs outside the classroom" [4]. In other words, the design and revision of first year introductory engineering courses has been one of the practices put in place to better motivate engineering students to learn and to persist in studying toward attainment of an engineering degree. However, we know very little about the results of these changes and specifically how students actually perceive these newly revised courses.

The student sample pertaining to this study includes two groups of students taking two versions of an introductory course in a general first year engineering program. In these programs, students take a variety of courses, including calculus, physics, chemistry and an introduction to engineering sequence. Important to realize is that very often the introductory engineering sequence courses are the only courses in these programs wherein students enroll with "engineering" in the title [5]. To put it differently, these courses usually represent the first exposure to engineering for thousands of future engineers enrolled in the general engineering program. The perceptions that students have about these courses may have a significant impact on students' decisions to persevere toward an engineering major, and possibly, into an engineering career in their futures. In fact, studies have indicated that students' perceptions of the practices in these engineering classes are related to their broader engineering-related motivational beliefs [1]-[5]. Thus, one way to better support students' motivation to learn and to persist in engineering is by understanding students' perceptions of the learning environment in these courses.

THEORETICAL FRAMEWORK

In this study, students' perceptions are defined as the extent to which students recognize each of the components of the MUSIC (eMpowerment, Usefulness, Success, Interest, and Caring) model of academic motivation. Specifically, the extent to which students differentiate that:

- they have control of their leaning (eMpowerment);
- the coursework is useful to their goals (Usefulness);
- they can succeed at the coursework (Success);
- the instructional methods and coursework are interesting (Interest); and
- others in the course (such as the instructor and their peers) care about learning (Caring) [6].

Thus, students' perceptions will be measured by using the MUSIC model inventory based on a questionnaire asking students about each of the MUSIC model components [6]. A key point is that students' perceptions, not necessarily reality, is the subject in this study. In other words, how students understand their class environment, or what students believe about the class is what will be examined.

Existing research on students' perceptions highlights that when students perceive a course to support their success, or short- or long-term goals, students tend to identify with a role in the content area of the class [7]. Consequently, students who identify more with certain domain also tend to be more motivated to remain in that domain [5]. Specifically in the engineering domain, some studies have concluded that perceived course experiences within first year engineering students are related to students' motivational beliefs, engineering major goals, and engineering career goals [6]-[1]. Thus, it is important to document how students perceive the different approaches specifically in engineering classes for first year engineering students who are just beginning to understand what being an engineer means and what role they can play in the engineering field.

By using the MUSIC model, we aim to better understand certain context within the academic setting, and to furthermore know which instructional elements in the classroom might influence students' academic motivational beliefs. More interestingly, each of the five MUSIC model components refers to a group of strategies that can be implemented in the classroom to support students' academic motivation [8]. In fact, Jones developed the MUSIC Model of Academic Motivation Inventory (MMAMI) with the purpose to help instructors in understanding motivation research. In addition, he intended to provide instructors with a tool that would offer both measuring students' perceptions of the learning environment, combined with teaching strategies intentionally linked to each of the five components likely to motivate students [6].

The components of the MUSIC model have shown to be distinctive with different students' samples; for example, Jones and Wilkins [9] provided validity evidence for the use of the MUSIC model inventory with middle school students. Further, Jones and Skaggs [11] validated the use of the MUSIC model inventory with a sample of 397 undergraduate students. They provided validity of the scores produced by the MUSIC Inventory with college students. Their results showed that each of the MUSIC model components was moderately correlated with the other four components, yet they demonstrated that each component was distinct [10]. One example outside the United States is work by Mohamed, Soliman, and Jones, wherein they provided a cross cultural validation of the MUSIC model Inventory among Egyptian university students [11]. Thus, validity evidence has been provided with different samples, including college students in the U.S., as well as within other cultures showing that the MUSIC model components are related yet can be considered separate constructs.

The MUSIC model is useful for this study not only because of its overall value to academic motivation, but also due to its effective use with first year engineering students. Jones *et al.* [5] documented that students who identified with the engineering domain were more likely to be motivated to pursue an engineering career. They also demonstrated that the MUSIC model consists of unique constructs in a first year engineering course [5]. Students' perceptions of the MUSIC model components in a first-year engineering introductory course were related to their engineering identification. Some of the components influenced students' sense of belonging in the engineering community, and the 'Success' component was significantly related with both engineering utility and program expectancy. In addition, engineering identification and program expectancy predicted students' choice of their undergraduate major, as well as their career goals in engineering [15]. These findings suggest that course approach can affect students' broader motivational beliefs and subsequently students' goals and career choices. Because a broader view of the results of changes in introductory engineering courses is necessary, the purpose of this study is to compare students' perceptions of the two versions of the introductory engineering course in order to offer a baseline for further discussion about how these changes help introductory courses meet the needs of first year engineering students.

RESEARCH QUESTION

Because existing research indicates that the design of the courses can affect students' motivational beliefs and career choices, it is important to compare students' perceptions of these courses. Accordingly, this study will seek to answer the following research question*: Is there a significant difference in students' perceptions based on the MUSIC model components between students enrolled in 1024 versus 1215 versions of a first-year introductory engineering course?*

METHODOLOGY

This section will describe measures of students' perceptions of two versions of an introductory engineering course. These perceptions will be based on each of the components of the MUSIC model of academic motivation [8]. The purpose of this study is to determine whether there are statistically significant differences in students' course perceptions between two groups of students: students who enrolled in the 1024 course and those who enrolled in the 1215 version of the introductory engineering course. This section will describe the methods by which data was collected, and the analytical methods that will be used to test for differences between the two groups of students. Results from this analysis will provide insight into how students perceived the two versions of the introductory engineering course.

Institutional Review Board

A research application form was submitted to the Institutional Review Board at the University. In order to protect the identities and privacy of the students included in the study, the participants will be assigned an anonymized, unique ID that does not allow the students to be identified. The Institutional Review Board reviewed the application and authorized the use of student records for this study.

Data collection

This study will use data previously collected by the engineering department, wherein the two versions of the introductory engineering courses were offered. Secondary data analysis is the use of existing data to investigate research questions others than those for which data were originally collected [12]. The main advantages to using existing data is speed and economy. In addition, the existing data was collected from a population ideal for the purpose of this study. The existing data will be used as measures of students' perceptions of each of the courses included in this study, which allows for comparisons between the two groups of students. The pre-existing data used for this study had been collected through a survey conducted at the end of the semester where both versions of the course were offered.

The Instrument

The purpose of this study is descriptive; the aim is to compare students' perceptions of the two versions of the introductory engineering course. The instrument used to collect the data was the MUSIC model of academic motivation inventory developed by Jones [8]. The instrument will be used intact as it was developed.

The MUSIC model inventory is a self-report instrument that includes 26 items related to the five components of the MUSIC model (empowerment, usefulness, success, interest, and caring). The five components have four to six items each:

- five empowerment items;
- five usefulness items;
- four success items;
- six interest items; and
- six caring items.

All are rated on a 6-point Likert-type scale ranging from strongly disagree to strongly agree. Students were asked to answer the questions based on their experience in the course, including assignments, activities, reading, etc. A sample item from each component is as follows:

TABLE I
SAMPLE ITEMS FROM THE COMPONENTS OF THE MUSIC MODEL

Sample Item	MUSIC model component
"I had the opportunity to decide for myself how to meet the course goals"	Empowerment
"The coursework was beneficial to me"	Usefulness
"I was capable of getting a high grade in the course"	Success
"I enjoyed completing the coursework"	Interest
"The workshop instructor was available to answer my questions about the coursework"	Caring

Participants and Setting

The participants in this study are general first year engineering students from the same cohort enrolled in either the 1024 or the 1215 version of a required introductory course at a large, public university in the mid-Atlantic United States. The engineering program included in this study fits into the taxonomy of engineering matriculation practices, developed by Chen and colleagues (2013), as a First Year Engineering (FYE) program. Students are admitted to the college of engineering as general engineering students, and are required to take an introduction to engineering sequence during the first year. In addition to those first-year introductory courses, this institution counts on a general academic advising, and a living learning community as part of the structure of its first-year program.

Students were randomly placed into either version of the course at the beginning of the semester. All students were emailed asking to complete the survey. The survey was open during a period of three weeks. Of the approximately 1,088 students enrolled in the 1024 version of the course, 1,008 students completed the survey, almost 93% and 810 consented participate in the study. Of the 338 students enrolled in the 1215 version of the course, 299 students completed the survey, approximately 88% and 240 consented participate in the study. Table 2 displays information about response rate for each of the courses. Table 3 shows participants' demographics by gender.

TABLE 2
RESPONSE RATE

	1024	1215	Total
Total	1088 (76%)	338 (24%)	1426
Respondent	1008 (93%)	299 (88%)	1307
Consent	810 (74%)	240(71%)	1050

TABLE 3
DEMOGRAPHICS

Gender	1024	1215
Female	23% (188)	15% (36)
Male	77% (620)	85% (204)
Total	808	240

DATA ANALYSIS

Descriptive statistics were analyzed to better understand data distribution and frequencies of the variables in the study. Completed participant scores were averaged by components of the MUSIC model, and were compared between the two samples of students. Data were analyzed using SPSS 24.0 software. The purpose of this study was to compare students' perceptions of two versions of the introductory engineering course. Neither an evaluation of the content of the courses nor students' learning or achievement, are included in the scope of this study. Determining if the two groups of students have different levels of course perceptions remained the central purpose of this study.

Variables

The independent variable Course Type represents which of the two courses each student is enrolled in, either the 1024 or 1215 version. This variable was represented as a dummy variable, with 0=1024, and 1=1215. The variables M, U, S, I, and C represented the examination of students' perceptions of each of the courses. These variables represented the average of each of the components of the MUSIC model: empowerment, usefulness, success, interest, and caring.

The Statistical Test.

A two-tailed, independent samples t-test, in which testing for possibility of a relationship is in both directions, was conducted to compare perceptions based on the MUSIC model component of students enrolled in the 1024 version to those who were enrolled in the 1215 version of the introductory engineering course. An independent t-test was employed to observe for statistically significant differences between means of two different groups [13]. The t-test employed in this study was performed with just one independent variable (the course), presented in two ways (1024 or 1215), and only one outcome (each of the MUSIC model components). Since the two samples came from the same student population, then it would be expected that their means were roughly the same. Thus, the null hypothesis would indicate that the sample means were very similar, revealing there was no statistically significant difference between the two groups on the dependent variable. If the null hypothesis was retained, the two group means differed only by sampling fluctuation, or by chance. An alternative hypothesis was that the two-sample means differ, wherein there was a statically significant difference between the two groups on the dependent variable.

Before conducting the t-test, preliminary analysis including: 1) Levene's test for equality of variances which measures how far out the data set is spread in the two groups of students, and 2) Shapiro-Wilk's test of normality were performed. Results of this preliminary analysis were used to determine whether the t-test should assume equal or unequal variances, as well as normal or no-normal data distribution. For the MUSIC variables, the variances were equal for 1024 and 1215 students, non-significative. The assumption of homogeneity of variance was assumed. The MUSIC variables were all significantly non-normal $p<0.05$. Then, a non-parametric t-test was used. P-values less than 0.05 were considered significant. Effect sizes were also calculated to demonstrate "the importance" of any differences since statistical significance can be affected by sample sizes.

RESULTS

Validity and reliability analysis were conducted prior to performing the t-test. A principal component analysis (PCA) was conducted on the 26 items in the MUSIC model inventory to explore the factor structures of the constructs with the specific dataset. Four components had eigenvalues over Kaiser's criterion of 1 and in combination explained 72.42% of the variance. Cronbach's alpha coefficient is generally used to measure internal consistency reliability among a group of items combined to form a construct. The reliability of the survey analyzed for this study will be addressed by running an internal consistency test calculating this coefficient. Criteria by Kline [14] suggest that a value of 0.8 is generally accepted; however, when dealing with psychological constructs values, below even 0.7 can be expected due to the diversity of the constructs being measured. These general guidelines need to be used with caution because the value of the Cronbach's alpha coefficient depends on the number of items in a construct. For this reason, the Spearman-Brown formula was used in cases where a construct has less than 10 items in a construct since Cronbach's alpha is sensitive to number of items in a construct [15]. That is to say, tests of fewer than ten items are unlikely to be reliable. Spearman-Brown formula is a correcting formula that compensate this in constructs with less than ten items [14]. Table 4 shows the reliability coefficients for the five MUSIC model components, all the cases were larger than 0.8 indicating that further analysis could be conducted.

TABLE 4
RELIABILITY COEFFICIENTS

Construct	N of items	Cronbach's Alpha	Course Type
Empowerment	5	.879	1024
		.885	1215
Usefulness	6	.925	1024
		.916	1215
Success	4	.880	1024
		.890	1215
Interest	6	.935	1024
		.915	1215
Caring	6	.871	1024
		.835	1215

The T-test analysis revealed that Empowerment, Usefulness, and Interest levels in students in 1024 did not differ significantly from students in 1215. Success levels in students in the 1024 course were significantly higher than in students in the 1215 course. Caring levels in students in the 1215 course were significantly higher than in students in the 1024 course. The effect sizes for these differences are considered small for all cases (<0.2). These small sizes suggest that the importance of the significance is small, the significance may be enhanced by a large sample size (Table 5).

TABLE 5
RESULTS

	Course type	N	Mean	SD	P value	Effect size Cohen's d
M	1	808	4.27	0.96	0.42	0.07
	2	240	4.20	0.99		
U	1	808	4.10	1.11	0.96	0.01
	2	240	4.09	1.14		
S	1	808	4.66	0.84	0.00*	0.15
	2	240	4.53	0.92		
I	1	808	4.08	1.05	0.32	0.09
	2	240	3.98	1.13		
C	1	808	4.98	0.78	0.00*	0.16
	2	240	5.10	0.73		

*p<0.05

DISCUSSION AND CONCLUSIONS

The mean score for Empowerment, Usefulness, and Interest components were somewhat lower for the 1215 version of the course than the mean score for those students in the 1024 version. However, these differences were not statistically significant (p=.42, .96, and .32 respectively). The Success component was significantly lower in the 1215 course (M= 4.53) than in the 1024 version (M= 4.66). According to the MUSIC model of Academic Motivation, the success component refers to students' beliefs that he or she can succeed if they put adequate effort. This includes students' beliefs in their own ability to complete assignments, class activities, investing a reasonable amount of effort. Some of the instructional strategies suggested by Jones [8] to support students' perceptions of success include: setting reasonable expectations, showing examples from former students, being explicit when describing your expectations and communicating with students, and matching the difficulty levels of class activities and assignments with the abilities of the students. It is possible that, because this was the first time the new version of the course (1215) was offered, many of these aspects were not possible to implement, for instance, offering students examples of assignments from former students. More research is needed to investigate why this difference. The Caring component was also statistically different between the two groups of students (p<.05). Caring refers students' perception that primarily their instructor is interested in their learning. This component was significantly lower in the 1024 course (M= 4.98) than in the 1215 version of the course (M=5.10). It is difficult to speculate why caring was significantly different in the two groups of students since the data include different instructors teaching different sections of each course; further research could disaggregate data by instructors providing more insight for this finding. Caring strategies suggested by Jones [6] being approachable and relatable to students, ensuring that students feel respected by you and other students, showing students that you care about whether they achieve the course objectives, and considering accommodating students when they experience extraordinary events [6].

Given the importance of students' course perceptions in their motivation to pursue an engineering degree, steps should be taken into consideration to continue the assessment of these courses to ensure that students are given the opportunity to have a better perception of their learning environment. The MUSIC model presents an inventory that could be implemented in the assessment of any course; psychometrics properties of the MUSIC inventory are similar across teaching approaches. The results of this study can help stakeholders include students' input for the overall assessment of the different curricular approaches in the courses. A broader view of the results of these changes is necessary for further discussion about how these changes make these introductory courses better to meet the critical requirements of first year engineering programs

This study compared data of students' perceptions of the first time the new version of the course was offered, analysis with the following cohort data should be carried out. Even though the effect size was small, those with design and curriculum development responsibilities should take these results into account when designing first year engineering introductory courses. In engineering education, if it could be shown that making a small change would improve students' motivation to learn and persist in a degree by a little effect size then this could be a very significant improvement, particularly if the improvement can be sustained over time.

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