Students' perceptions in a first year engineering classroom and their relationship with behavioral and cognitive engagement

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Abstract - **Motivation is considered as a strong predictor of student engagement and learning. The MUSIC model of Academic Motivation can be used by instructors and researchers to assess students' perceptions of the MUSIC model components (eMpowerment. Usefulness, Success, Interest, and Caring) for an activity or course. The purpose of this pilot study was to investigate the relationship between first year engineering students' perception of the MUSIC model of motivation components for an introductory engineering course and engagement. Methods of data collection included class observation and an online survey completed by 23 out of the 32 (72%) students in the class. Findings indicated that, for this class, the Interest component was positively correlated to both Behavioral and Cognitive engagement. In addition, data suggested that perception of the Caring component had the highest value while perception of Success had the lowest value. Factors supporting students' perception of each component were identified. Implications for practice in the classroom and overall conclusions were specified based on the findings of the study.**

Index Terms – Engagement, First-Year Engineering, Motivation, MUSIC model.

INTRODUCTION

Students' engagement in school plays a key role in students learning and success [1]. Active engagement is necessary to promote meaningful learning. First year engineering introductory courses are part of an initiative designed to recruit and retain more students to engineering. However, engineering students' motivation tend to decrease and is easily influenced by various factors including the classroom environment, especially during the first year [2]. The MUSIC model of Motivation provides a useful lens to examine students' perceptions of a course. In the same way, this model is useful to identify elements related to the course content and the instructor that support or inhibit students' engagement.

Given the importance of engagement for students' learning and success, the purpose of this investigation is to examine the relationship between students' perceptions of the MUSIC model components (empowerment, usefulness, success, interest, and caring) and engagement in an engineering classroom with first year students. Students' perceptions of the MUSIC model will be investigated using the MUSIC model inventory by Jones [3] and engagement will be measured using Behavioral and Cognitive engagement scales developed by Wang, Fredricks, Ye, Hofkens, and Linn [4]. In addition, these quantitative results will be compared with qualitative data based on class observations and students' responses to open ended questions in order to get a better understanding of students' perceptions.

The following research questions guide this investigation:

What are students' perceptions of empowerment, usefulness, success, interest, and caring in a first year engineering classroom?

What is the relationship between students' perceptions of empowerment, usefulness, success, interest, and caring and students' behavioral and cognitive engagement?

What factors support or inhibit students' perception of empowerment, usefulness, success, interest, and caring?

METHODOLOGY

Description of the class:

All engineering students at this university enter into a general, interdisciplinary engineering program and select specific disciplines after their first year. There is a two-semester required Foundations of Engineering course sequence; the first course is focused on design analysis while the second course is focused on engineering programming and students design a prototype as part of the final project. The courses share content which is integrated over both semesters. There is an average of 32 students per section. The curriculum is purposefully designed to include strategies such as working with real time data acquisition, modeling systems, and designing products and systems of students' interest. Activities and a project with an emphasis on engineering design and problem solving skills are incorporated and students are exposed to the different engineering fields and majors. The class meets twice per week for 75 minutes each time.

Participants:

Participants in the sample for the current study are part of the Foundations of Engineering II class. During this semester, 23 out of the 32 students in the class completed the online survey (72% response rate). One student didn't finish the survey. Four participants were female and 18 participants were male.

Data Collection:

This pilot study examined data from two sources: class observations and an online survey that included: 1) the MUSIC inventory scales, 2) Engagement scales, and 3) open ended questions from the MUSIC model inventory. The use of multiple sources of data was designed with the purpose to provide a more robust method of studying the relationship of the MUSIC model components and students' engagement in the class. The version used for the MUSIC model was the college student version for middle of the semester. Behavioral and Cognitive engagement scales developed by Wang et.al [4] were included. In addition, open ended questions from the MUSIC model inventory were included in order to have a deeper understanding of students' perceptions of the course. Figure 1 shows the data sources for this study.

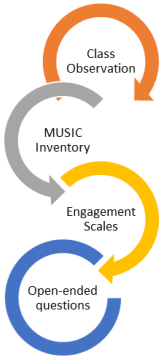

FIGURE 1.
DATA SOURCES USED IN THE STUDY.

PROCEDURE

Class Observation

The class observation was conducted for the duration of one class session in the course (75 min). The researcher sat at the back in the classroom and took notes about the setting and the behavior of the instructor and students during class. The researcher observed students and instructor during class as they conducted an activity related to drawing. Students interacted with each other and with the instructor while doing the assigned activity. Observation notes are represented when appropriated in the findings of this article.

Survey

The week after the observation was conducted, students were given an online survey with the MUSIC inventory, engagement scales, and open ended questions. The survey remained open for a week. When giving the online survey, an email was used in order to explain the purpose of the study. Approval was granted prior to the collection of any data with exempt status by the Institutional Review Board (IRB). The MUSIC model inventory is formed by closed-ended questions asking the participants to rate the level of agreement with statements using a 6 points Likert scale. The Engagement items included in the survey were taken from the scales developed by Wang et. al [4] using a 5 points Likert scale.

Data analysis

Broadly consistent with concurrent mixed method research, quantitative and qualitative data was collected and analyzed nearly simultaneously. Descriptive statistics including means and standard deviations of the MUSIC model inventory and engagement scales were computed. Correlations between the MUSIC model components and behavioral and cognitive engagement were calculated. Then, the results of the quantitative analysis were integrated into the interpretation of the qualitative results from the class observations and students' responses to the open ended questions.

Initial codes were developed by using thematic analysis through reading the responses to the open-ended questions included in the survey. The 23 students' responses were analyzed line by line with the aim to provide initial codes. Interpretative coding inductively enabled themes to emerge from the data being guided by the initial research questions. These codes were associated to the corresponding MUSIC model component.

FINDINGS

Research Question 1

The first research question was: What are students' perceptions of empowerment, usefulness, success, interest, and caring in a first year engineering classroom? Descriptive statistics such as means and standard deviations were calculated. Table 1, and Figure 2 and 3 show the results of these calculations.

TABLE I
MEAN VALUES OF MUSIC MODEL COMPONENTS AND ENGAGEMENT SCALES

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Empowerment	22	1.00	5.80	3.3091	1.42057
Usefulness	22	1.00	5.20	3.3364	1.45063
Success	22	1.00	5.17	3.2727	1.26882
Interest	22	2.50	6.00	4.4091	1.00755
Caring	22	3.00	5.83	4.5955	.83186
Behavioralengagement	22	2.63	4.88	4.0170	.58413
Cognitiveengagement	22	3.00	4.75	3.8523	.48433
Valid N (listwise)	22				

Note: MUSIC model components are rated on a 6-point Likert-type scale and Engagement scales are rated on a 5-points Likert-type scale.

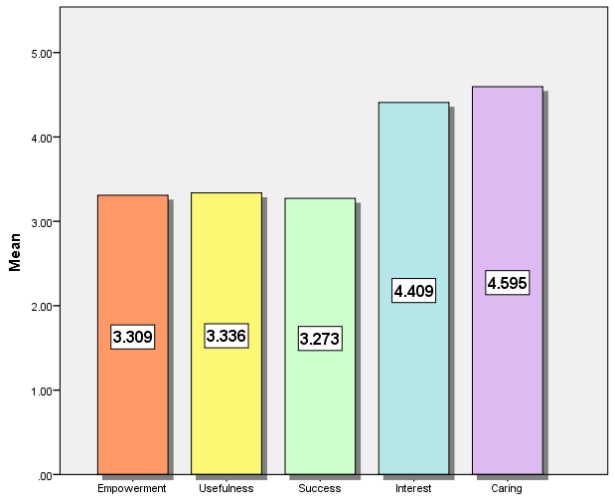

FIGURE 2
MEANS OF EACH OF THE MUSIC MODEL COMPONENT

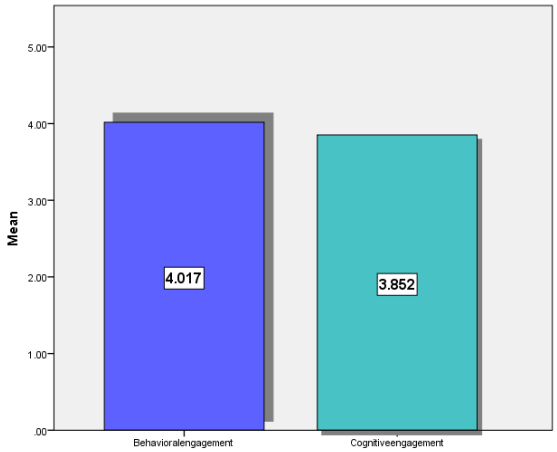

FIGURE 3
MEANS OF BEHAVIORAL AND COGNITIVE ENGAGEMENT IN THE CLASSROOM

Research Question 2

What is the relationship between students' perceptions of empowerment, usefulness, success, interest, and caring and students' behavioral and cognitive engagement? For this question, Pearson correlation coefficients were computed for all the variables: the MUSIC model components and behavioral and cognitive engagement. Figure 4 shows the significant correlations between the MUSIC model components and behavioral and cognitive engagement.

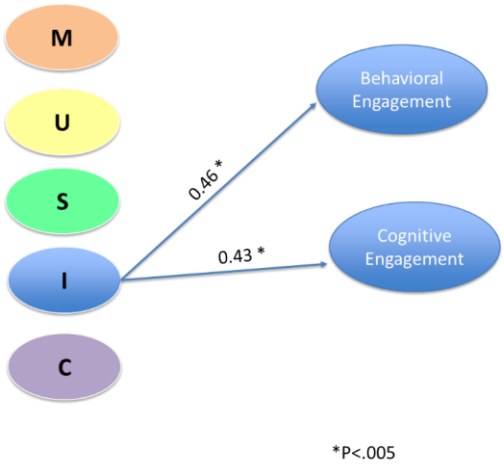

FIGURE 4
SIGNIFICANT CORRELATIONS BETWEEN THE MUSIC MODEL COMPONENTS AND BEHAVIORAL AND COGNITIVE ENGAGEMENT.

Research Question 3

What factors support students' perception of empowerment, usefulness, success, interest, and caring in an engineering classroom? For this question, exploring the data obtained through the open ended questions included in the online survey and the observation notes allowed to identify specific factors that support students' perceptions of empowerment, usefulness, success, interest, and caring. The responses to these questions were coded. The following tables show the final codes describing the factors supporting students' perceptions.

TABLE II
CODES FOR THE EMPOWERMENT COMPONENT

Which aspects of this course give you control over this course?		
Component	Codes	Definition
eMpowerment M=3.31	Design Project Team work Time to complete assignments	Very open-ended design project Ability to communicate with other engineering students to succeed Opportunity to plan and complete assignments ahead of time

TABLE III
CODES FOR THE USEFULNESS COMPONENT

What do you find useful about this course?		
Component	Codes	Definition
Usefulness M=3.33	Programming practice Team work Hands-on activities	Activities using Matlab and Inventor software Opportunities to work in a group Opportunities to do "practical stuff", drafting.

TABLE IV
CODES FOR THE SUCCESS COMPONENT

What makes you feel successful in this course?		
Component	Codes	Definition
Success M=3.27	Completion of assignments Getting good grades	Opportunity to figure out complex problemsSpecific mention of getting good grades in the class

TABLE V
CODES FOR THE INTEREST COMPONENT

What do you find interesting about this course?		
Component	Codes	Definition
Interest M=4.40	Software (Matlab and Inventor) Design Project	Opportunities and activities to learn how to use Matlab and Inventor software. Opportunities and activities related to learn how drones work, sketching, hands-on things, any open-ended and creativity parts.

TABLE VI
CODES FOR THE CARING COMPONENT

What does the instructor do to provide you with the impression that she cares about whether you learn the course content and do well in the course?		
Component	Codes	Definition
Caring M=4.59	Willingness to help Detailed explanations Availability	Opportunities for asking questions, getting answers. Specific mention of ways instructor explains material in class. Specific mention of ways instructor makes efforts to be easily available.

DISCUSSION

As suggested by Table 1, the data indicates that for this class, students' perceptions of success (M=3.27), empowerment (M=3.30), usefulness (M=3.33), and interest (M=4.40) fall in the range from 3.27 and 4.40, indicating that in general, students in this class have a moderate perception of these components. The mean value for caring (M=4.59) was the highest among the components of the MUSIC model, falling in the upper third of the scale value. This indicates that students generally have a high perception of teacher caring in this class. The mean values for students' behavioral and cognitive engagement fall in the upper third of the scale value, M=4.01 and M=3.85 respectively, indicating that students in this class generally have a high behavioral and cognitive engagement.

Exploring the relationship between the MUSIC components and students' behavioral and cognitive engagement, Pearson correlations coefficients were computed for all the variables. The data indicated that students' perception of the interest component was positively associated with both behavioral and cognitive engagement r= 0.463 and r=0.432 respectively, ($p < 0.05$ level, 2 –tailed). In the following sections, findings associated with each component of the MUSIC model will be described.

Perception of success means that "students believe they can succeed in the course" [5]. In the dataset, participants identified that the completion of assignments and getting good grades made them to feel successful in the course. For example, several participants mentioned that knowing how to use the Autodesk Inventor software and getting a code run in Matlab software made them feel successful in the course, as illustrated by students' responses to the open-ended questions:

"*Making mat lab code run, creating a part on inventor. These are the two things that are rewarding on a personal level" and "Getting all the points on an assignment"*

These comments show that students' perception of success in the course is highly influenced by their performance in the activity. Some participants also mentioned that providing rubrics and giving more specific expectations would make them to feel more successful, as illustrated by comments from the open ended question responses:

"If a rubric or what was expected of us were given, I would feel more successful in this course. I feel successful when I complete an assignment with minimal help from friends".

Such comments are aligned with strategies to support success by Jones [5]: "Students don't know whether or not they can succeed unless they know what's expected of them" [5]. Clear and explicit expectations are needed for students to feel they can succeed or not.

Although quantitative data suggested that perception of success had the lowest mean value (M= 3.27, SD= 1.26), the data from the open ended questions also identified activities that students consider make them to feel successful in the course, such as the completion of assignments and getting good grades. It is important to

consider, when interpreting the quantitative findings, the time in the semester when the survey is conducted. The class observation and the survey were conducted during the week students had received their grades for the Midterm exam. Thus, if students didn't perform well in the exam, it might influence on their perception of success in the class. In addition, during that week students were meeting with their instructor in order to review the status of their final design project and most of them realized they were behind since they needed to test the prototype during the following week. This might also had influenced on their perception of success.

Empowerment refers to the students' perception of having control over some aspects of their learning [5]. For this MUSIC component (M= 3.30, SD= 1.42) students reported three factors that give them the perception of having control over the course: 1) The Design project, 2) Teamwork, and 3) Time to complete the assignments. However, students also reported that "having to complete the assignments in a very specific way" lowered the perception of empowerment in the class.

Usefulness (M= 3.33, SD= 1.45) refers to students' understating about how the course, content, assignments, and activities are useful to their short term or long-term goals [5]. Three codes emerged from the qualitative coding: 1) Programming practice, 2) Team-work, and 3) Hands-on activities. The programing practice was expressed by most of the participants as relevant to what "they wanted to do" as expressed in this sample comment: "Good for teamwork; MATLAB and Inventor seem relevant to what I want to do." At the same time, some participants commented that they don't find it useful when the instructor talks about "abstract stuff" and "ethics".

Caring represents the students' perception that the class instructor "cares about their learning and about them as a person" [5]. In the dataset, this component had the highest mean value (M=4.59, SD= 0.83). Three main factors emerged from the data as indicators of this perception: 1) Instructor willingness to help, 2) Detailed explanations, defined as specific mentions of ways instructor explains the material in class, and 3) Instructor availability, defined as specific mentions of ways instructor makes effort to be easily available. No data from the students' responses to the open-ended questions indicated factors that inhibit students' perceptions of this component in the classroom.

Interest refers to students' perceptions that "classroom activities and/or course topics are interesting" [3]. Two factors were identified from the qualitative data that support students' perception of interest in this class: 1) Activities to learn how to use Matlab and Inventor software and 2) Activities to "learn how drones work, sketching, hands-on things, and any open-ended and creativity parts". These responses show that students consider these activities interesting and are aligned with the quantitative results for this component (M= 4.40, SD= 1.00). In addition, this component is significantly related to both Behavioral and Cognitive Engagement (r=0.43 and 0.46 respectively). Behavioral engagement (M= 4.01, SD=0.58) refers to the practices that students direct toward school and learning, including attention, participation, concentration, and homework completion while cognitive engagement (M= 3.85, SD= 0.48) refers to student mental efforts directed towards learning [6]. These findings provide some evidence that catching students' attention through activities is positively related to students' engagement in class. In other words, students who are interested and enjoy the activities tend also to be more engaged in the class.

A variety of motivation theories could be related to the findings of this study. We choose to relate the finding to the Expectancy- Value model [7]-[8]. This model theorizes that individual's performance, persistence, and task choice are shaped by both the individual's expectancy for success and values [8]. Expectancy explains the individual beliefs regarding their ability to do the task whereas task-value explains the individual beliefs regarding the importance of a task [9]. For example, students' statements such as "Ability to learn about the aspect of professional engineering" is an example of the utility value included in the task-value beliefs part of Eccles model. This specific quote indicates that learning aspects of professional engineering has a value for students. Another quote: "I like the idea of the project" is an example of students' enjoyment of the design project in the class. This is an example of intrinsic interest value. In the dataset, this specific construct was positively related to behavioral and cognitive engagement. It is important to consider students' perceptions of these constructs in the class since this model predicts students' choice to persist in an activity. Especially for first year engineering students, it would be beneficial to understand how these perceptions can be better supported in efforts to increment retention rates in engineering colleges.

PRACTICAL IMPLICATIONS

Exploring the findings from this pilot study allows to identify specific areas for improvement. Figure 5 presents some specific recommendations to be applied in this class to better support students' motivation. These recommendations are based on strategies to support students' motivation as described by Jones [5]. For example, students reported that having to complete the assignments in a very specific way made them feel they don't have control over the course. By providing students with choices, when possible, within assignments or providing the rational when requiring students to do something in a very specific way might be beneficial to increase students' perceptions of empowerment or control over the course. In addition, the data indicated that students believe that "abstract topics like ethics" are not useful to their goals. Using guest presenters to share reasons why they find ethics useful and at the same time relating this topic to students' lives might help students understand better how these type of topics is relevant to their goals as future engineers. Likewise, participants described that "If a rubric or what was expected of us were given, I would feel more successful in this course". Setting reasonable expectations

and putting these expectations in writing can help students better understand what is expected of them, increasing their perception of success. In like manner, decreasing debilitating anxiety is suggested in order to minimize the negative effects on students' motivation. Participants in this study recognized that not receiving a lot of information about how to complete the project "is not a very good way to do things". The nature of the project in this course is based on the Problem Based Learning (PBL) technique where students are given an authentic problem and students work with classmates to solve it. This might cause students undue stress, going beyond an optimal level of anxiety and arousal in students. By having students to list what is causing them to feel stressed about the project and determining whether there is some way to help them to reduce this stress can be beneficial to keep the optimal level of arousal in students. Finally, only positive outcomes were reported by students related to the caring component. However, the findings of this study in general, imply that explaining the differences between high school and college can be beneficial specifically for this class. Explaining students these differences can help them to perceive that the instructor cares about their success and at the same time can enhance the other factors that seem to impede student's perceptions of the other components of the MUSIC model.

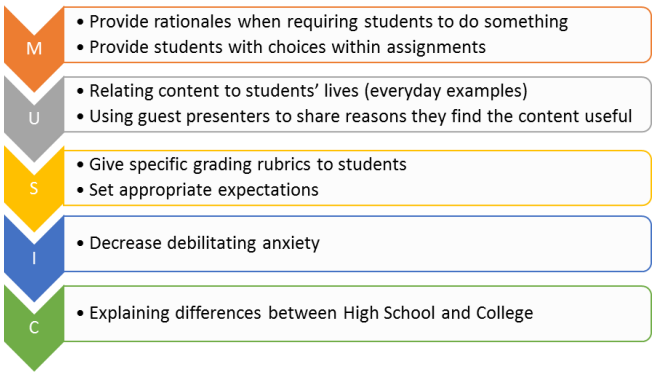

FIGURE 5
PRACTICAL IMPLICATIONS DERIVED FROM THE FINDINGS OF THE STUDY BASED ON STRATEGIES SUGGESTED BY JONES (2015)

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