Work in Progress: Utilizing the MUSIC Instrument to Gauge Progress in First-Year Engineering Students

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***Abstract* — One of the "Grand Challenges in Engineering Education" is to engage students in their own learning. Student engagement is widely seen as a necessary component driving the success of active learning methodologies. The Music Model of academic motivation was developed as a means to make the human motivation literature accessible to instructors interested in improving courses to increase student motivation and engagement. The model has a reliable and validated survey instrument that assesses 5 components of academic motivation. The model has been applied in two contexts relevant to our current project: in course design and improvement to assess the impact of changes on student motivation and learning, and second, it is used to examine students' motivational perceptions and their relationship to other learning-related constructs. MUSIC has been used in K12 through higher education, and across a variety of fields.**

In this Work in Progress report, we had two purposes: First, we sought to test the use of the Music Model in an engineering course, since little research has been conducted in engineering courses to date. Second, we sought set the stage for developing a community of practice focused on student engagement with a common and straightforward assessment methodology for the first-year engineering community. Our broad goal is thus to leverage the MUSIC components as one metric for gauging improvement of student engagement for our own first-year engineering program, then eventually a community wide tool for first-year engineering programs broadly. The MUSIC scale inventory data (n=221) was collected electronically in 3 sections of a first-year engineering course at a mid-western technological university. A confirmatory factor analysis replicated the 5-factor MUSIC Model. An ANOVA revealed no differences in student motivations between our three-course sections. This result validates our ability to offer similar experiences across sections and instructors within our first-year course. Multiple comparisons between factor scores demonstrated significantly higher motivation reported on both the caring and success factors as compared to the others. In addition, the interest motivation factor was significantly lower than all other factors. These findings demonstrate the utility of the Music Model within engineering education. We discuss future research to develop a process for instructors to understand the results and make formative decisions for future course iterations. Further, we suggest future research re-establishing the link between the various motivational factors and educational outcomes such as GPA, course grades, retention in STEM, etc. We propose that global events, such as the pandemic, may have resulted in changes in students' priorities regarding education, thereby altering previous findings regarding the importance of specific motivational factors on educational outcomes.

Keywords—Student Engagement, MUSIC model of Student Engagement, Assessment of Student Engagement, Engineering Education, First-Year Engineering Education, Engagement.

I. INTRODUCTION

One of the "Grand Challenges in Engineering Education" is to engage students in their own learning. According to Vest [1], then president of the National Academy of Engineering, engineering education must focus on the environment in which students learn. While the content is changing at an amazing pace, facilitating a learning environment that fosters student ideas, inspiration, and empowerment will be critical in the 21st century. "Students are driven by passion, curiosity, engagement, and dreams." [1 page 236]. We need students who are technically and creatively able to solve the challenges of tomorrow. The MUSIC model of Academic Motivation was developed to help instructors apply motivation research to the design of instruction by providing an organizational framework of current models of motivation.

Student engagement is widely seen as a necessary component driving the success of active learning methodologies. The Music Model of academic motivation was developed as a means to pull together a plethora of literature focused on human motivation in a manner that would make core results from the literature on student motivation accessible to educational researchers at large through a validated instrument for the construct of student engagement [2, 3]. The Music Model and inventories can be used by instructors/ designers to design courses to promote student motivation, identify factors that may be hindering student motivation, and conduct research to determine the effect of strengthened student motivation on common student learning outcomes.

Work by Jones and colleagues [i.e., [3]] has established the reliability and validity of the instrument as a measure that assesses distinct, yet correlated, subtypes of motivation. It provides a parsimonious yet multidimensional representation of the various forms of academic motivation that drive academic engagement and performance. The development of the Music Model of academic motivation also addresses a need for instructors who seek to improve courses to increase student motivation and engagement. The Music Model survey instrument is increasingly used for the assessment of 5 components:

1. **eMpowerment –** students' strength of control that they perceive they have in their own learning.
2. **Usefulness** – students' perceptions of how the knowledge or skill will be useful for their goals.
3. **Success** – students' strength of belief that if they invest appropriate time and energy, they can be successful in the course.
4. **Interest** – students' strength of attention to the course content will increase emotional engagement (liking, passion, intrigue, etc) and cognitive connection (focus, attention, etc.) to the course.
5. **Caring** – students' strength of belief that the instructor cares about their learning, and hence about their individual welfare.

The MUSIC Model was designed to be used in two applied contexts relevant to our current institutional environment. First, it is used by instructors to design more engaging courses followed by an assessment of student learning and motivational changes to gauge the effectiveness of course changes. Second, it is designed to examine students' motivational perceptions and their relationship to other learning-related constructs. MUSIC has been utilized in both formal and informal educational settings, in K12 through higher education, and across a variety of fields [4].

Previous research with the MUSIC Model within engineering education is limited and has been largely conducted by the team of researchers who developed the instrument. For example, Jones and colleagues [5] found that motivational beliefs, as assessed by the MUSIC Inventory, affected student effort, grades, and career goals as well as student identification in the engineering profession. Further, they suggested developing courses with motivational goals in mind in an effort to strategically foster student motivation. Mora and colleagues [6] used the MUSIC framework in their efforts to identify ways to implement problem-based learning (PBL) strategies in engineering education in a manner that increased student motivation.

We had two purposes for the current work. First, we sought to test the structure of the Music Model in an engineering course; research using the survey instrument for the Music Model in engineering settings has not been widespread. We hypothesized that our results would be consistent with the Music Model structure of 5 correlated types of motivation. Second, we intended to leverage the MUSIC components in a program improvement manner to set the stage for the systemic use of this instrument as one metric in gauging improvement of student engagement in a program-wide study of the effectiveness of our first-year engineering program. For example, differences in student perceptions as assessed by the MUSIC factors could inform our use of a shared curriculum across course sections. We hypothesized that evidence supporting our implementation of a shared curriculum would exist if significant differences in factor scores between sections of the course were not present. In addition, we demonstrate with follow-up analyses how the factor scores may be useful in course planning.

II. Methods

The MUSIC scale inventory [3] data was collected through a google survey for students enrolled in 3 sections of a first-year engineering course at a mid-western technological university. The course was structured such that each of the 3 instructors utilized the same content, timeline, and major assessments (i.e., a shared curriculum). Students were offered course credit for completing the inventory.

A total of 221 students completed the MUSIC inventory (n=35: section 1; n=98: section 2; n=88: section 3). The inventory consisted of 26 items utilizing a 6-point Likert type agreement scale (1 = strongly disagree; 6 = strongly agree), assessing the 5 factors related to academic motivation per the MUSIC Model: empowerment, usefulness, success, interest, and caring.

Two different approaches to analyses were utilized. First, we performed a confirmatory factor analysis to determine if the 5 MUSIC subscores as reported by Jones and Skaggs validation studies [3] were replicated in our engineering education sample.

Second, we conducted an ANOVA to investigate the presence of similarities/differences in subscores between the 3 sections to inform program improvement. We also conducted a series of paired sample t-tests to look for differences between the factor scores across sections to guide course improvement decisions.

III. Results

We conducted a confirmatory factor analysis utilizing JASP (version 0.16.3) to determine how well our data fit the 5 subscale model identified by Jones and Skaggs [3]. Fit indices supported the Music Model, with $\chi^2(289) = 456.950$, $p < .001$, CFI = .999, RMSEA = 0.051, and GFI = .997. Table 1 contains the individual items' (sorted by factor) R^2 values, factor loading, and residual variance. As shown in Table 1, R^2 values ranged from a low of .594 (one of the caring factor items) to a high of .954 (one of the success factor items). The 2 items (item 1, in the caring factor; item 2, in the interest factor) with the lowest loading and highest residuals were removed to see if the goodness of fit indices improved, but they did not. Thus, all items were kept in the factor analysis.

Once the factor structure was verified, subscores were calculated as a mean across the 4-6 individual items contributing to each subscore (See Figure 1, Appendix) as per Jones and Skaggs [3]. Mean subscores ranged from a low of 4.37 (interest factor) to a high of 4.99 (caring factor). See Table 2 in the Appendix for the subscale descriptive statistics.

Next, ANOVA was utilized to investigate whether subscores differed among the 3 class sections. No significant differences were found between class sections for any of the 5 subscores (p values ranged from .914 to .149).

To examine differences between subscore values across the sections, a series of paired samples t-tests were used to compare the factor scores from the 221 respondents. Caring (M = 4.99, SD = .9185), the factor with the highest rating, was significantly higher than interest (m = 4.14, SD = 1.0570), empowerment (M = 4.39, SD = 1.0167), and usefulness (M = 4.41, SD = 1.0849). The second highest factor, success (M = 4.96, SD = .8923), was also significantly higher than

empowerment, usefulness, and interest. No differences existed between caring and success factors. The subscore with the lowest mean was interest (M = 4.13, SD = 1.0570), which was significantly lower than all other subscores. The final comparison revealed that no significant difference existed between empowerment (M = 4.39) and usefulness (M = 4.41). Figure 1 in the Appendix depicts the scale score differences.

IV. Discussion

We sought to utilize the MUSIC model of academic motivation scale to assess motivation in a shared-curriculum first-year engineering course. We had two purposes for introducing this method of assessing student motivation. First, we felt that the results would shed light on our ability to offer the shared curriculum across sections and instructors from a continuous improvement perspective. Second, we were interested in the validity of the model within an engineering curriculum, as very little data exists with this model in examining first-year engineering student motivation.

A confirmatory factor analysis demonstrated good fit indices replicating the MUSIC Model factor scores. Two items, inventory items 1 and 2, had relatively low factor loadings and elevated cross factor loadings. However, the removal of these items diminished the fit indices so we kept them in the model. As stated, very little research using the Music Model in engineering education exists. Our work, confirming the utility of the model within engineering education, specifically for first-year programs, should allow others to use the inventory to assess student motivation and make curricular decisions with confidence.

We also examined factor scores between course sections to assess the use of a shared curriculum. An ANOVA revealed no differences in student motivations as measured by the factor scores between our course sections. This information validates our ability to offer similar experiences across sections and instructors within our first-year course. Finally, collapsing across course sections, we did a series of paired comparisons between the individual factors to understand areas in which motivation was strong and/or could be identified for improvement. The caring subscale and the success subscale did not differ statistically; Both caring and success were significantly higher than the 3 other subscores, with differences in subscore means ranging from .28 to .85 on the 6-point scales, and an average difference of approximately ½ a point. In terms of the remaining 3 subscores, interest was rated significantly lower than empowerment and usefulness (which did not statistically differ). We hope to present these findings in discussions among course section instructors as planning for the next academic year commences. For example, knowing that the interest score was significantly lower than all other factor scores may prompt the adoption of different assignments, spanning new or different engineering specialties or applications in an attempt to improve interest amongst students. Further, knowing that the students perceived their instructors as caring about their learning and success should be interpreted by instructors as confirmation that their efforts matter.

V. Future Work

Efforts for continuous improvement in our first-year engineering program may focus on improving interest in the course/content first. We will share the results of this work with the instructors and hope to work with them to re-assess the impact of any changes that they opt to make. The goal of having interesting course content or projects is to establish personal interest in students.

Motivation research has differentiated the constructs of personal interest and situational interest. Personal interest is a relatively stable orientation toward activities, people, or things. It is enduring, and context general. [7]. For example, some individuals are sports enthusiasts - an example of personal interest.

Situational interests, the type of interest measured by the MUSIC Inventory [2], are typically more temporary toward something novel, stimulating, or surprising. It tends to be more spontaneous and context-specific.[7] Of relevance to the current discussion is situational interest in academic contexts. An interesting concept, image, or comment by a teacher may attract a student's attention through situational interest. Hidi and Baird [8] hypothesized that situational interest has two stages - one in which interest is triggered, and a second stage in which that interest is maintained. Most importantly is the finding that the maintenance of situational interest is essential in the development of personal interest [9]. Thus, the goal of course work would be to trigger students' situational interest, maintain it through project-based or cooperative learning, provide scaffolding in which students with initial situational interest can further explore the topic, and finally aid in the establishment of the more enduring personal interest by providing opportunities or challenges to further develop knowledge.

We anticipate one direction of the current research will be creating a process through which an instructional team is guided through an evaluation of various course/lesson components to examine them from the lens of the Music Model of motivation. The original inventory authors sought to develop one instrument to measure several various forms of motivation without the need for instructors to be familiar with the vast literature on motivation. We see the logical next step as providing instructors with the "framework" or platform for interpreting the results of the inventory in a manner that formatively guides future course iteration changes and/or curricular decisions. In sum, we believe the development of a user-friendly formative process that both guides and tracks instructor knowledge and decisions would take the MUSIC inventory from the theoretical research space that was necessary for the development of the model to the applied space of assisting instructors in the use of the model's results in designing their own courses. We anticipate developing an onboarding program to train and acculturate faculty. In the longer run, we hope to establish an ongoing and outward-facing development of a community of first-year programs utilizing the base of the MUSIC Model and methodology. First-year engineering program representatives may contact the authors to consider engagement in this community building activity.

We believe that a repository for program representatives to obtain and submit various applications of the MUSIC model in engineering education would not only inform individual instructors and programs but would promote a community of stakeholders (instructors, chairs, curriculum coordinators, assessment specialists, etc.). We envision that such a MUSIC toolbox would contain templates (for comparing the various

factor scores within classes/assignments), sample forms to track intended course alterations and outcomes, guidelines for the application of results, and informational materials to collaboratively assist researchers and practitioners in the development of highly motivational engineering education offerings.

Secondly, we also encourage the use of the Music Model in hypothesis testing regarding the development of student motivation over time, and the impacts of motivational types on academic outcomes. For example, as suggested by Hidi and Renninger [9], increased personal interest can develop when students' situational interest is attracted and maintained. However, given the recent pandemic and reports of the impact of the pandemic on students, we must wonder if any enduring changes in students with lived "COVID" experiences will necessitate a re-examination of the effect of these motivational indices on factors such as student retention and success. In other words, our study, conducted during COVID, was able to confirm the presence of the 5 MUSIC factors as assessed on the inventory. However, the foundational research linking these factors to academic achievement and retention in engineering may have changed, or be changing in the present.

Questions abound regarding the new post-covid student. Is their attentional focus elsewhere based upon experiences or life lessons experienced during COVID? There are some intriguing findings being published regarding changes in student motivation post-COVID. For example, Daniels, Goegan, and Parker report a shift in student focus from an approach motivation to an avoidance motivation [10]. Specifically, student interest in course content, learning, and achievement decreased while their avoidance of bad grades and focus on cheating increased.

Wang and colleagues found a significant decrease in student situational interest following the move to online instruction at the onset of COVID [11]. Perhaps when faced with a pandemic one's motivational focus changes based upon changing priorities. There has been a good deal of discussion on possible differences in the current undergraduate matriculation profile of incoming students from those of five years ago. Re-establishing the connections between motivation and educational outcomes should be revisited as global events such as a pandemic, economic crisis, or other lived experiences may impact the importance of these specific motivational factors on student success in engineering education.

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APPENDIX

Table 1. MUSIC Inventory Item Parameter Estimates

Factor	Indicator	R^2	Factor Loading	Residual Variance
Empowerment	20. I had the opportunity to decide for myself how to meet the course goals.	0.817	0.904	0.183
	11. I had the freedom to complete the coursework my own way.	0.683	0.826	0.317
	18. I had options in how to achieve the goals of the course.	0.815	0.903	0.185
	3. I had control over how I learned the course content.	0.630	0.794	0.370
	7. I had flexibility in what I was allowed to do in this course.	0.728	0.853	0.272
Usefulness	25. In general, the coursework was useful to me.	0.946	0.972	0.054
	12. The coursework was beneficial to me.	0.860	0.927	0.140
	13. I found the coursework to be relevant to my future.	0.848	0.921	0.152
	16. I will be able to use the knowledge I gained in this course.	0.814	0.902	0.186
	21. The knowledge I gained in this course is important for my future.	0.878	0.937	0.122
Success	19. I was confident that I could succeed in the coursework.	0.838	0.915	0.162
	17. I felt that I could be successful in meeting the academic challenges in this course.	0.958	0.979	0.042
	10. I was capable of getting a high grade in this course	0.628	0.793	0.372
	5. Throughout the course, I felt that I could be successful on the coursework.	0.824	0.908	0.176
Interest	15. The instructional methods used in this course held my attention.	0.857	0.926	0.143
	4. I enjoyed the instructional methods used in this course	0.739	0.859	0.261
	23. The instructional methods engaged me in the course.	0.848	0.921	0.152
	9. I enjoyed completing the coursework.	0.664	0.815	0.336
	8. The coursework was interesting to me.	0.786	0.886	0.214
	2. The coursework held my attention.	0.595	0.772	0.405
Caring	24. The instructor was willing to assist me if I needed help in the course.	0.829	0.911	0.171
	6. The instructor cared about how well I did in this course.	0.843	0.918	0.157
	26. The instructor was respectful of me.	0.831	0.912	0.169
	22. The instructor was friendly.	0.915	0.957	0.085
	14. I believe that the instructor cared about my feelings.	0.750	0.866	0.250
	1. The instructor was available to answer my questions about the coursework.	0.574	0.758	0.426
Indicator number reflects the order in which the items were presented in the inventory				

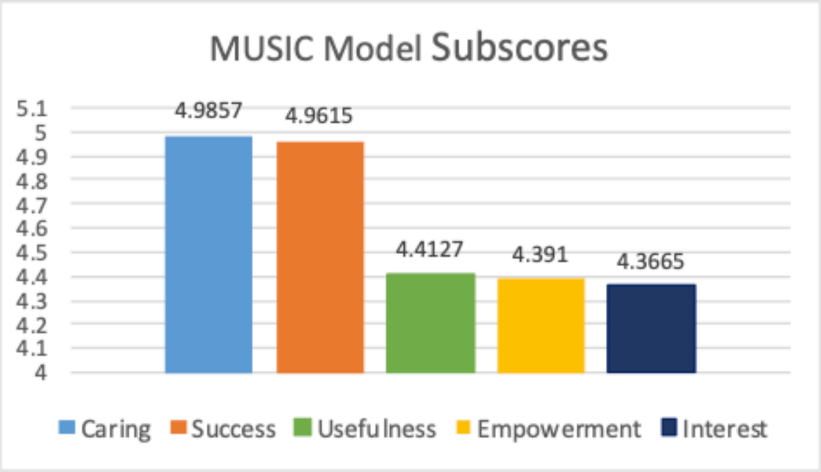

Figure 1: Scale Scores Differences

Table 2: MUSIC Inventory Subscore Descriptive Statistics					
	N	**Min**	**Max**	**Mean**	**St Dev**
Caring	221	1.17	6.00	4.9857	0.91848
Interest	221	1.00	6.00	4.3665	0.98376
Empowerment	221	1.00	6.00	4.3910	1.01673
Success	221	1.75	6.00	4.9615	0.89232
Usefulness	221	1.00	6.00	4.4127	1.08486
Valid N (listwise)	221				