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Student Engagement with a Nontraditional First-Year Engineering Project Theme

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Abstract

For many students, first-year engineering (FYE) courses are their first formal introduction to the content and practices associated with becoming an engineer. At this stage, many students' interests and conceptualizations of the discipline are still developing. The content of the first-year courses plays a significant formative role in the evolution of this understanding. Many first-year courses are designed with this in mind, placing an emphasis on core engineering skills like teamwork, and taking a project from conceptualization to completion. Many also construct these project experiences around traditional engineering skill sets like programming or mechanical systems. These skills are important, but place students who had no access to them prior to arriving at their university at a disadvantage in their teams. To be as flexible as possible, students must be prepared for both technical and creative projects. Creative design can be incorporated into technically focused projects, but it ultimately may be more effective to include creative design as a foundational aspect of the project instead. To explore this, an alternative project was developed with a focus on an unorthodox topic: musical instruments. One objective of this design was to encourage students to consider a broad variety of future paths within engineering. One question that this alternative project poses, however, is how students in the first-year program will be able to make connections between the project and their engineering paths. The purpose of this qualitative investigation is to examine how first-year engineering students at a large public Mid-Atlantic university describe their engagement and interest in an engineering design project with a nontraditional theme. Data for this study are drawn from student responses to a collection of short answer questions as well as several reflection assignments completed during the project. In combination, these encompass the affective, behavioral, and cognitive dimensions of student engagement. Together, these three dimensions provide a comprehensive view of how students engage with the project itself, their teammates, and others in the class. Furthering the understanding of how students view and engage with a nontraditional project may expand options for curriculum design in first-year programs.

Background and Objectives

In the mid-2000's, a call went out to integrate the teaching of science, technology, engineering, and mathematics into what we now collectively refer to as STEM [1]. Since that time, additional initiatives have suggested that it might be even more beneficial to integrate the arts into STEM learning, creating STEAM. Some even argue that it should be pushed even further, adding additional study of the societal implications of STEAM research and work, further lengthening the acronym to STEAMS [2]. For this paper, the focus will remain on STEAM and its implications for the first-year engineering curriculum.

Students' experiences in their first-year engineering (FYE) classes are crucial as they conceptualize what it means to be an engineer. Instructors must consider what disciplinary knowledge should be imparted to students at this stage of their study, while also deciding how it might most effectively be transferred [3]. For many FYE programs, the result is a hands-on project focused on one or more disciplines of engineering. Oftentimes, these projects are technical, focusing on subjects like robotics [4], [5] or boat design [6]. Others involve a service-learning based approach, collaborating with local initiatives to address challenges in the community [7]. Previous projects at this study's institution included the design of solar ovens, remote-controlled car attachments, autonomous model airplanes, and aesthetic vertical axis wind

turbine blades. Despite this variety in theming, many of our FYE projects fail to incorporate the arts in any meaningful way. This is problematic for two primary reasons. First, the finalist nature of many traditional STEM projects shifts the focus away from the design process and purely onto the final product, whereas STEAM projects have often balanced the final outcome with an examination of the design process itself [8]. When students are more concerned with having a final product that meets a set of strictly defined objectives than they are with learning and practicing the process of iterative design, it is more likely that they miss out on creative and original solutions. The second issue compounds upon this. As Oosthuizen and Vlok [9] identify, there is limited structural support for creativity in the engineering design process at both the academic and industrial levels. If organizations are not fostering and supporting creativity as part of their work culture, they potentially lose out on new and novel ideas [10]. From matches to the microwave, the contributions of accidental discovery and experimentation cannot be understated.

In an effort to combat this lack of creative focus in FYE design projects, a new open-ended project model was proposed, drawing in the arts by tasking student teams with constructing a new and novel musical instrument. Further details for this project can be found later in this section. Projects with a nontraditional nature are sometimes challenged with the question of whether students would engage with them in a meaningful and relevant way. However, for students to get value from the project, it must spark their interest and motivate them to devote their time and energy to it [11]. Furthermore, students should be able to make connections between the project and their broader engineering experiences [12]. To determine how successful the project was in its pilot run, two questions had to be answered. First, how engagement was going to be defined, and subsequently whether the project had engaged students based on the settled-upon definition.

Despite a wide variety of interpretations of the theory, at a high level, there is some agreement about what constitutes student engagement. As Laird et al. [13] propose, engagement is the combination of two factors: the time and effort students put into activities related to their success and the institution's level of support for student participation in these activities. This definition is further expanded upon by Simmons et al. [14] to highlight the dual nature of resource availability in engagement. For effective engagement to take place, students must put forth the resources, namely time and effort. They must also then be supported by the university administration's resources, including programs, facilities, and personnel. Of these two components, there is widespread agreement regarding the former, whereas the university's responsibilities are less frequently mentioned [15]. For this study, this construct is being applied specifically within the context of an FYE classroom, meaning that the administrative resources are instead the responsibility of the teaching team and organizing structures that undergird the course structure itself. As such, this study focuses on both the effort that students put forth in completing the project, but also how the project supports and provides opportunities for students in turn. This study draws upon several generally accepted dimensions of engagement [12], [16], [17]. These can be found in Table 1. In exploring how students engage with the music-focused project, this study seeks to examine all three dimensions listed. It is important to understand not only how the project motivates students to put in effort, but also if and how they are able to tie their work on the project into their broader engineering coursework and experiences. For the project to be considered a successful alternative, it should succeed in engaging students across all three dimensions, or at least provide a means for doing so with improvements following the initial pilot run.

Table 1: Dimensions of Engagement, adapted from Groccia [12]

Dimension of Engagement	Description
Behavioral	Students put forth effort and participate in the learning process, should also be persistent in their studies
Affective	Students must have interest in the engagement experience, which typically results in increased motivation, enjoyment, and commitment
Cognitive	Students must be able to cognitively process the experience and link it to previous experiences

Ultimately, the purpose of this research study is two-fold. First, the study seeks to address the following research question:

> How do students engage with engineering coursework when it is approached through a project outside of traditional "engineering" themes?

Secondly, this paper seeks to reflect upon and share the experience and outcomes of facilitating the pilot run of a non traditionally themed first-year project.

Music-Focused Project Details

The semester-long project required students to design and construct a musical instrument that met a specific set of constraints and criteria (Table 2). There were a number of deliverables associated with the project, both physical and written. Physical deliverables included several prototypes, as well as the final instrument. There were three showcase sessions throughout the duration of the project, where students brought their prototypes to class for other teams to examine. The first required students to demonstrate three proof-of-concept prototypes. They then used feedback from this session to pick and develop one prototype for the second session. Further development led to the final showcase and demonstration of their finished instruments. Written deliverables included requests for materials, team status updates, examinations of ethics with respect to the project, instructions for building the instrument, and a final report accompanied by a video of the team discussing and demonstrating their instrument's functionality. As part of the final report, students were also required to find and speak with musicians and get further feedback about their designs. Students also created 3D models of their instruments in a computer-aided design (CAD) software program that was introduced as part of the course.

Table 2: Summary of Criteria and Constraints

Constraints (Required)	Description
Range of Pitches	At least 2 octaves or 24 distinguishable pitches
Volume	At least 70dB at regular playing intensity
Tunability	Must be tunable and stay in tune for at least 15 minutes of play
Playstyle Restriction	Must be playable while wearing a mask, air from external sources allowed
Construction Requirements	Use only tools and materials available to a typical high school machine shop, must be constructable in less than 8 hours of work time.
Cost	Less than $60 to build and maintain (batteries, etc.)
Criteria (Optional)	**Description**
Novelty	Novel in appearance, sound, or function
Beyond the Constraints	Larger pitch range or volume range, lower cost or build time
Ease of Use	Easy to learn and/or play
Versatility	Polyphonic, chromatic, or multiple playing modes
Transportability	Ease of transportation and set up

Positionality

The authors recognize their own positionality with respect to the research conducted here. The music-focused project was originally the idea of this paper's secondary author and was delivered in practice by both authors. This carries the risk of influencing the analysis, as both authors would like to have seen that the project was successful in meeting its objectives. However, this iteration of the project was a pilot run and as such, both authors were interested in identifying improvements to make before running it again in the following semester. This research work is one effort to this effect and as a result any neutral or negative feedback will be included impartially as important dimensions of the improvement process.

Methods

Participants

The participants in this study were drawn from two sections of a second semester first-year engineering course at a large public Mid-Atlantic university. These sections occurred "off-cycle," here meaning that they took place in the first semester of the academic year. At the

study's institution, these sections are typically intended for students who have transferred from another institution, students aiming to transfer into the college of engineering from within the university, students who are repeating the course, and students in other majors who wish to take the course out of personal interest. As a result, not all of the students are first-year students, some have prior engineering experience, and a few may not be pursuing engineering at all beyond the scope of the course. Per a "not research" determination by our Institutional Review Board, all of the students in both sections were included in the dataset, assuming that they completed at least one of the surveys or assignments used in the study as outlined below. A total of 139 students were included in this study. Pseudonyms will be used when referring to any of the students during the discussion of the findings.

Data Collection

Data for this study comes from two primary sources: a series of short surveys conducted at the end of class sessions and a selection of reflective assignments throughout the course of the semester. The former, known as exit surveys, occurred at the end of each class and were consistently structured. Students were given five minutes at the end of each class to complete the survey but could take longer if they needed. Students were required to complete the surveys for attendance credit, but were not explicitly required to answer every question, nor were there any expectations for the quality or length of their responses. The first question was multiple choice, and the answer was given at the end of class as part of the means for collecting attendance information in the course. The second question varied but was typically an opportunity for students to give feedback on a subject related to what was covered in class that day. The third question was consistent week-to-week and served as a general means to collect broad feedback and insight from students. Both the second and third questions were short answer, meaning that responses were typically a sentence or two long. The data being used from these surveys comes from the second question of the exit surveys from six weeks of class wherein students were asked to reflect on the semester project. The six specific questions can be found below:

1. Have you ever made a connection between the musical instrument project and your experiences with engineering and other engineering coursework? If so, what? (Week 6)
2. Would you consider an engineering career in the arts? Did you know this was an option before this semester? (Week 8)
3. Has the instrument project provided opportunities for effective collaboration with your team members? How has it done this? (Week 9)
4. Is this project the type of work you expected to be doing in a first-year engineering course? Why/why not? (Week 10)
5. Has the semester's project stimulated your interests in the arts from an engineering perspective? (Week 13)
6. Previously, the projects in this course have included making wind turbines, drones, and solar ovens. Would you have been more interested in one of those premises? Would the effort you put into the project have changed? (Week 14)

During the course of the semester-long project, students were asked to complete several reflective assignments. Most were specifically focused on progress on the project itself, but the final one was a creative reflection assignment intended to cover the entire semester. The exact content of student responses was highly variable for many of these, particularly the final

assignment, and as a result individual responses may or may not be relevant to the research questions addressed by this study. However, a sufficient number of responses included insightful reflection on how students engaged with the project that they have been included as a secondary source of data in this study.

Analysis

At the end of the semester, the exit survey responses and relevant assignments were compiled. For the exit survey questions, each response was coded as either "affirmative" or "negative, in line with the "yes or no" structure of the questions. Inconclusive or irrelevant responses, as in the case of a student writing "perhaps" or an answer that was not related to the question, were left out of the analysis. For question two, answers were coded for each part of the question, resulting in codes like affirmative/affirmative, affirmative/negative, and so on. Some students only answered one part of question two, whereupon their responses were coded in the style of null/affirmative. These responses were then tallied up and compared for the sake of easy visualization. No further quantitative analysis was performed on these counts for this paper.

Following this surface-level categorization, analysis shifted to the content of these responses. It was at this stage that student assignments were also drawn into the analysis. Due to the inconsistency of the content of these assignments, their contribution to the analysis was minor in comparison to the exit survey questions. Both sets of data were coded descriptively, guided by the three dimensions of engagement defined by the selected framework [12]. Certain questions were designed to target specific dimensions of engagement, but all were coded openly across all three of the dimensions based on student responses. Following this first round of coding, a second round was conducted to identify themes that emerged within each dimension. Finally, these codes were analyzed across all three dimensions to identify any patterns that emerged within and across dimensions [18]. By conducting the analysis in this way, the data can be understood at the levels of individual questions, dimensions of engagement, and holistically.

Results

In order to present the results from this study, the counts and select responses are presented for each of the six exit survey questions respectively. In the following discussion section, there is a broader exploration of each of Groccia's [12] dimensions of engagement and how the student responses to both the exit surveys and assignments related to them. In order to protect students' privacy, pseudonyms have been assigned to each respondent whose response is quoted, paraphrased, or directly referenced. Some responses are paraphrased for clarity or student privacy.

Exit Survey Question #1: Have you ever made a connection between the musical instrument project and your experiences with engineering and other engineering coursework? If so, what?

Table 3: Exit Survey Q1 Responses - Week 6

Total Responses	Affirmative	Negative	Other/Irrelevant
125	57.6% (72)	38.4% (48)	4% (5)

The first exit survey question targeted the cognitive dimension of engagement, seeking to find if students were able to connect their work on the project to their broader education in engineering (Groccia, 2018). For many, connections were present, but most were vague. Several students described how the group work they were doing was reminiscent of what they had done for other

projects, or that the engineering design process was familiar to them from prior work. Many others connected the project to their physics classes, identifying waves and the properties of sound as the bridging point. A few others noted that the 3D design elements of the project would be important in a wide range of engineering applications. For a small handful of students, there were very specific connections that could be drawn to the project. Michael shared that "a significant amount of this project reminds me of when I was doing a project on earthquake resistant buildings. There's a significant amount that you have to understand about resonance and interference that overlaps." Another student that was able to make a connection was Cheryl, who shared that "a professor in my Engineering Research Seminar came in and talked about a music-based lab and it reminded me of this class!" Cheryl was able to connect new engineering experiences back to the work she had done up to that point on the instrument project, whereas Michael related the instrument project back to previous work. This indicates that these connections are bidirectional in nature.

A substantial number of students were not able to draw connections to their prior experiences, but most of the responses in this category contained little detail. Most were simply "no," or some variation thereupon. However, some students did discuss the lack of connection. Ishir struggled to make connections to the project due to how different it was from the rest of his engineering experience thus far. One student, Tamara, indicated that she was not able to make connections to other engineering coursework due to it being her first official engineering class. This was a less common comment, despite the class being part of the first-year engineering sequence.

Exit Survey Question #2: *Would you consider an engineering career in the arts? Did you know this was an option before this semester?*

Student responses to this two-part question were marked yes/yes if they both were considering the career and knew about it previously, yes/no if they were considering but had not known previously, and so on. Of the 107 responses, 37 students did not answer both parts of the question. Their responses were coded for whichever part of the question they had responded to, with the other portion left blank. These raw codes can be found below in Table 4. From there, the total number of students who would consider a career in the arts was calculated, along with the number who were not considering it, and the counts of how many students knew and did not know previously. These totals are shown below in Table 5.

Table 4: Exit Survey Q2 Raw Data - Week 8

Yes/Yes	Yes/No	No/Yes	No/No	Yes/-	No/-	-/Yes	-/No
6.4% (7)	25.9% (28)	7.4% (8)	25.9% (28)	8.3% (9)	17.6% (19)	0.9% (1)	7.4% (8)

Table 5: Exit Survey Q2 Totals - Week 8

Would Consider a Career in the Arts	Would Not Consider a Career in the Arts	Knew Prior to the Course	Did Not Know Prior to the Course
43.9% (43)	56.1% (55)	20.3% (16)	79.7% (63)

Responses to this exit survey were varied. Like the previous question, many students answered with some combination of yes and no directly. Of those who were considering a career in the arts, a greater proportion of them had not previously known of the option. Some, like James, Michael, and Brittany, expressed surprise and excitement at this new potential career path. Mary and Anthony expressed confusion and a desire to know more, with Mary being the more excited of the two. Most of those who answered yes to both questions were brief in their response, but

Jonathan described his interest by explaining that "the design process can be a work of art sometimes." Cheryl once again drew upon another experience, excitedly proclaiming "Sound Engineering! And yes – my high school engineering teacher loved talking about it because he was really involved with the theater department."

Many students expressed that their lack of interest in the arts stemmed not from a distaste for the arts, but from a greater interest in other domains of engineering. Perhaps the most upfront of these students was Kyle, who shared that "No I wouldn't [consider an engineering career in the arts], I would prefer to work in a manufacturing plant. I had no idea there was an engineering career in the arts." He reiterated this disinterest in his end of year creative assignment as well. Other students responded similarly, citing interests in electrical systems or more technical things. Bill kept an open mind, though he did not immediately see himself working in the arts, as he explained "I'm pretty set on my interest, although they can be related so it's possible. Depends where my interest develops as I get further in the program." Conversely, some students did directly state that they had a distaste for the arts. Alejandro expressed that he would not consider the arts "because I'm not a good drawer." Don was even more blunt when he stated that "I personally have no interest in art so I don't think I would ever be interested."

Exit Survey Question #3: Has the instrument project provided opportunities for effective collaboration with your team members? How has it done this?

Table 6: Exit Survey Q3 Responses - Week 9

Total Responses	Affirmative	Negative	Other/Irrelevant
112	95.5% (107)	2.7% (3)	1.8% (2)

Bridging both the affective and behavioral dimensions of engagement, this question sought to understand how well the project supported students by providing opportunities for meaningful team collaboration. Overwhelmingly, students felt that the project did so. Unfortunately, those who did not were generally brief with their responses. The one student who explained more simply stated that the music project did not provide any more opportunity than any other project would. However, for those who answered in the affirmative, there was significant variation in the responses. The majority of the affirmative answers cited the need to get work done as the primary motivator for this interaction with teammates. The tone of these responses was mixed, with some students using language that suggests that they begrudgingly meet with their teams out of necessity. Others were more positive, like Gideon, who appreciated that the project "made [him] work with people I haven't met outside of class." Conversely, Michael highlighted the benefits of being able to work in class, as it provided him regular opportunities to meet, even if they weren't the only times he worked with this team. A few students even chose to talk about the types of work that the project had provided them the opportunity to work on as a group. Cameron, for example, felt like his team had made the most of their work time in the first-year makerspace:

> The work we have done in the [first year] lab feels very visceral. It doesn't feel like we're working on a corporate or academic project. When you're building something physical, your progress both looks and feels more rewarding.

Altogether, students were almost unanimously in agreement that the opportunities for engagement were there, but not every student seemed to enjoy this fact.

Exit Survey Question #4: Is this project the type of work you expected to be doing in a first-year engineering course? Why/why not?

Table 7: Exit Survey Q4 Responses - Week 10

Total Responses	Affirmative	Negative	Other/Irrelevant
109	67.0% (73)	30.3% (33)	2.8% (3)

The fourth exit survey sought to understand how students connected the project to their expectations of the first-year curriculum. The majority of students shared that the project was indeed the type of work they had expected to do. Those that answered in the affirmative, however, tended to focus more on the processes associated with the project, rather than the theme of the project itself. Some students described the construction elements and adherence to the engineering design process as aligning with their expectations. Others discussed that they had anticipated problem solving and group work. Ishir described doing "project similar to this" in his high school engineering class, so he was among those unsurprised by the work he was asked to do. Overall, those who said that the project matched their expectations tended to focus heavily on the work they were doing.

Conversely, those who answered in the negative tended to place their emphasis on the theming of the project. Bill was among the students who expected to produce a physical product, but he "wasn't entirely expecting a musical instrument." Some students expected a more technical focus to the work, with some delving into more specific expectations like circuits. A few expressed displeasure with the structure of the project and the course more broadly, having expected "harder stuff" or a larger number of smaller projects. A small subgroup of those who answered "no" emerged during analysis, being composed of students who had not expected musical instruments but were surprised to enjoy it as much as they did. This group is encapsulated simply by Sharif, who answered "No, I thought there would be more math and stuff. But I like this."

Exit Survey Question #5: Has the semester's project stimulated your interests in the arts from an engineering perspective?

Table 8: Exit Survey Q5 Responses - Week 13

Total Responses	Affirmative	Negative	Other/Irrelevant
122	62.3% (76)	25.4% (31)	12.3% (15)

The fifth exit survey question provides a retrospective look at what the second question asked early in the semester. For many students, the semester project provided a means to explore a largely unknown facet of engineering and consider the possibilities that the intersection of engineering and art could offer. Students answering in the affirmative fell into distinct groups. Some explained that the project had given them a greater appreciation for the role of engineering in instrument production and the music industry. Others reflected more broadly on how they had discovered they could be creative and do engineering. Meera went one step further, even reevaluating how she would approach challenges, explaining that "It's definitely made [me] want

to take on problems and challenges from a more creative standpoint first, instead of trying to begin from a technical standpoint." The final group of students in the affirmative category largely found value in parts of the project inspiring their personal interests in engineering. Alejandro, for example, reflected that his team's instrument had inspired him to learn more about circuits.

While some students felt that the project had not stimulated their interests in the arts, others felt that it had confirmed their dislike for music and musical instruments. In the former group, students often explained that they had other interests and were simply not convinced that they would prefer working with the creative arts down the line. Cheryl explained that she had "nothing against this class, it's just not what I enjoy the most." Other students had stronger negative feelings towards the project theme. Kyle lamented that, "This project compounded my feelings on not liking instruments already and definitely confirmed them." Don expressed similar sentiments, "Not really at all. I had no interest in artistic representation in engineering before the semester, and this course more or less cemented that fact." It seemed that those who felt most strongly about this question in either direction had arrived to the course with existing feelings about the intersection of engineering and the arts. For those who were indifferent, the responses seemed to go either way, with some students deciding that engineering in the arts was not for them and others embracing the newly discovered option.

Exit Survey Question #6: Previously, the projects in this course have included making wind turbines, drones, and solar ovens. Would you have been more interested in one of those premises? Would the effort you put into the project have changed?

The final exit survey question was sent to students at the end of the semester, near completion of their musical instrument project. The responses to this question were the most convoluted of the six. Question six was coded in the same way as question two, as they are both two questions in one. The results of this can be seen below in Table 9. The authors were not satisfied with the wording of this question, as it lacked context and poorly defined the previous project iterations. The one-to-two-word descriptions provoke images of quadcopters and large-scale wind turbine designs, which exceed the scope of the course and do not reflect the reality of the other projects, which are actually a small unidirectional autonomous airplane, and blades for a demonstration-scale vertical axis wind turbine. For some students, these projects seemed very appealing. For others like Cameron, the perceived technical complexity of these projects was intimidating and served as a deterrent from putting the same level of effort into their work. For future research this question would need to be rephrased and additional background on each of the project concepts would have to be introduced.

Table 9: Exit Survey Q6 Responses - Week 14

Yes/Yes	Yes/No	No/Yes	No/No	Yes/-	No/-	-/Yes	-/No
13.9% (15)	15.7% (17)	5.6% (6)	4.6% (5)	25% (27)	21.3% (23)	1.9% (2)	2.8% (3)

These data are further sorted into categories in Table 10 below. A greater number of students only answered a single part of the question than in question two, though it is unclear why.

Table 10: Exit Survey Q6 Summary - Week 14

Prefer Other	Did Not Prefer Other	No Change in Effort	Would Increase Effort	Would Decrease Effort	Unclear Change in Effort
63.4% (59)	36.6% (34)	52.1% (25)	29.2% (14)	12.5% (6)	6.3% (3)

Most respondents indicated that they would have preferred one of the previous projects, with two distinct groups among those who provided some explanation for their answer. The larger of the two groups was composed of students who had specific interests that featured in one of the three previous projects listed. George, for example, had previous experience building and racing drones. Zach shared that "Wind turbines would've been very interesting to me because I really like renewable energy and things that interact with fluids." Among those in this former group, many explained that their interests made them inclined towards a different project, but that the instrument project had been a good experience nonetheless. The other group that preferred the previous project iterations tended to not be fond of the musical theming. Carrie expressed frustration that "If the project was changed to something that I was interested in I def[initely]would have put more effort [into] it. I didn't play any musical instruments, so I was very confused by a lot of things." Michael shared the lack of musical experience Carrie describes, though he acknowledged that "I don't think it would have affected the effort I put in the project, but I may have enjoyed working on it more." Even among those who would have preferred another topic, many were confident that the amount of effort they would have put in would have remained consistent. Some students highlighted other aspects of their engagement with the project unprompted however, like Michael above. Bill similarly highlighted that while "I always give my all into a project," he "might have felt less stressed working on one of those instead." Several others expressed similar sentiments, drawing attention to the disconnect between effort put in and enjoyment for some students.

Among those who preferred the music-oriented project to the theoretical alternatives, opinions ranged from indifference to staunch support. At the former end of the spectrum, students like Omar shared, "I think our semester's project was unique and fun enough to constitute as an engineering project. Although the other projects are cool, this one was just as cool." At the other end, Brittany took a firm stand that "I would find those far less interesting and probably put in less effort due to the lack of interest. Instruments are way cooler." Of the six students who preferred the music project and expressed that their effort would have changed with a different project, only one thought they would have put more effort in with a different project, explaining that he "enjoyed the freedom with [the] instruments." The others seemed strongly attached to their project, with one even calling his team's instrument "our own little baby. We cared for it and like that it was our original."

One divisive element that spanned students who responded across the range of codes was the creativity of the project. This came up again and again for those who enjoyed the instrument

project and those who did not. Most who liked the creative elements preferred the instrument project to the others, like Jonathan:

> I like the uniqueness of this project way more than the previous ones. I personally like seeing the creativity people put into making instruments over just the same three projects. So, my effort for this one is way higher since I feel like I could be more creative in the decision-making process.

Others directly juxtaposed the creativity required for the instrument project with the perceived rigidness of an alternative project. Diego summarized this position clearly:

> I feel like wind turbines would have been more interesting on a practical, functional level, however, the instrument as a project takes a functional aspect and adds a much more creative twist to it, which makes it more enjoyable.

On the opposite side, some students felt stuck due to the creative nature of the project, like Anthony. He commented that "making a custom instrument requires creativity, which I don't have." This divisiveness around creativity was evident in responses to several of the other exit survey questions as well.

Discussion

The discussion of the results for this study is broken into two sections, one each to address both objectives of the study. The first will address the various dimensions of student engagement whereas the second will discuss the implications of the work for future implementation of creatively oriented FYE projects.

Behavioral Engagement

The responses to exit survey questions three and six make it clear that the instrument project prompted students to put forth the effort required to complete the assigned work. Students overwhelmingly agreed that opportunities were available to collaborate with their peers. Despite poor response rates to the change in effort part of question six, a fair number of students said that their levels of effort would not have changed, even with a project they may have liked more. Some students said they did not put in as much effort as they otherwise would have, while a few others said they put in more. These responses seem to indicate that the nontraditional topic of the instrument project did not deter most of the students from working hard on the project and remaining persistent in their efforts.

It is difficult to draw conclusions about the source of students' motivation to engage with the project however, given that the project and its associated assignments made up a significant portion of the overall grade in the course. Many of the students who said that their effort would not have changed simply expressed that they gave 100% - and sometimes 110% - to every project that they work on. While these statements reflect positively on students' work ethics, they do little to clarify whether there was any meaningful connection between student work and the project topic. Perhaps the most salient takeaway with regards to behavioral engagement is summarized by Melanie: "I might be more motivated if a project idea is cool, but that depends a

lot on how the project is presented." In other words, the theming of the project may matter less than the project being presented in an interesting way.

Affective Engagement

The matter of affective engagement is difficult to address based on the data presented. While it was clear that some students felt passionate about the content of the project and engaged with it actively, many other students did not feel the same interest. Every student is going to have different preferences, particularly in a general FYE course that all engineering students take regardless of their intended discipline, and more so in an offering of the course that includes non-engineering students. This can be seen even within the data of this study given the split in student preferences between the instrument, drone, solar oven, and wind turbine projects. As such, it is not unreasonable to suspect that some groups of students within a class might not feel motivated by the project theme regardless of what it is, which is what was observed anecdotally in this course. The task then shifts to ensuring that the project makes use of other best practices that promote engagement, like promoting collaborative learning and providing adequate academic challenge to the students [13].

Cognitive Engagement

Of the three dimensions of engagement chosen for this study, cognitive engagement was the most consistently reported. The majority of students were able to make connections between the project and their broader engineering curriculum. Most of these connections drew upon the project's basis in the engineering design process and collaborative teamwork. That these associations are largely basic or simple may be because these are first year students with limited experience with engineering to begin with. However, these associations once again emphasize the importance of presentation over theming in effective implementation of FYE projects. Those students who were not able to make connections were generally hung up on their lack of experience with musical instruments. There is a discernible difference in the mindset of each group of students. Those who can make connections see the project as an engineering project built around music, whereas those who cannot seem to perceive it as a music project within an engineering context. The cause for this difference is not entirely clear from the data presented here, but it is possible to theorize a remedy. If the project was clearly and repeatedly framed as an engineering project that happened to be built around a creative topic, students might be more likely to see the connections to the rest of their coursework.

The Issue of Creativity

Throughout the data from the exit surveys, students were divided on whether the creative nature of the instrument project was a motivator or a deterrent. While this has already been discussed with respect to each dimension of engagement, it also indicates a broader issue in engineering education. Creative problem solving is a commonly desired competency for professional engineers, sometimes being labeled as one of the defining factors separating ordinary and outstanding engineering [19]. In an FYE context where students feel like their capacity to complete a project is limited by their belief that they simply aren't intrinsically creative, this is concerning. In the course, the nature of creativity as a learned skill was discussed as part of a

lecture but this message was not received equally well by all students. Anthony's response to question six, for example, highlights how some students reached the end of the semester still harboring the belief that they were not capable of succeeding at the project due to its roots being in music. On the opposite side, Abby's final creative reflection assignment contained a strong message:

> My whole life, I have been stuck in the mindset that I simply am not a creative person nor can I out-train being uncreative. I hated art or anything that involved drawing, simply because I told myself I was not creative enough for [it]. This class has certainly taught me otherwise. I may never be the best at drawing, or painting, or anything of that sort, but it does not mean I am not creative.

There is an important distinction in defining creativity and the subsequent role of engineering courses in promoting it. The creativity that FYE courses can target is the generation of original and novel ideas utilized in the engineering process. This is separate from proficiency in activities traditionally associated with creativity like art and music. It is important when introducing the concept of creativity in the engineering classroom that the separation between these two categories is made clear. Creativity is a complex idea, with numerous perspectives and interpretations [9]. Nonetheless, it is important to recognize that the way that creativity is presented in the classroom may have significant impacts on how it is perceived by students.

Implications for Further Implementation

In its pilot run, an FYE project based around the construction of novel musical instruments demonstrated its capability to engage students across all three dimensions described by Groccia [12]. There was disagreement among students regarding the theming of the project, but most were nonetheless motivated to work towards a successful final design. The nontraditional focus on the creative domain of musical instruments proved to suit some students better than others, and vice versa. Ultimately, what became clear from reviewing student responses was that this project was received in a similar manner to previous topics despite its divergence from the traditional theming of most similar FYE projects. Given the disparate opinions regarding the role of music in the project, it may be worth considering offering students multiple options for project themes when resources allow for it. The results of this study indicate that the students with the highest motivation to succeed on the project were those most fond of the theme so giving students the option to pursue a problem or question of their choice might best encourage them to engage.

One of the major outcomes of this study entirely separate from student engagement was recognition of the fact that the possible connections between engineering and the arts are not well communicated to students. This is evidenced by exit survey question two most prominently, but also in question five. The majority of respondents had not previously known of the potential to hold an engineering career in the arts. Despite fewer than half of the students expressing an interest in pursuing such a career, it is still important for them to have information about the potential of work in such a field, particularly in the first year when they are still choosing their

engineering disciplines. The fifth exit survey question further builds upon this, highlighting that for many students, the instrument project had fostered some interest in the relationship between engineering and the arts. Given how broad a field engineering is, it is crucial that students are able to make informed decisions about their futures. Utilizing the project in an FYE course progression is one potentially powerful tool to broaden students' horizons.

For future implementations of similar creatively oriented projects the key takeaway is that the framing of the project matters as much if not more than project topic itself. It became very clear that the students who were most capable of relating the construction of an instrument to their other engineering courses viewed their FYE work as engineering at its core. To this end, it would likely be valuable to make some connections for the students throughout the semester to get them thinking and to make the relationship clear for those who are struggling to do so themselves. Similarly, introducing creativity and its role in the design process – and its separation from the disciplines of art and music – could help to better motivate those students who doubt their own abilities. Simply listing "novelty" as a criterion for the quality of a final project may not be enough, as students in this course frequently got hung up on what the term actually meant in practice. The project as described for this study is undergoing revision for future use, but this iteration may serve as a useful reference for those trying to design or deliver similar creatively oriented engineering projects at the FYE level or in any other applicable context. Design programs have been implemented for younger students as a way to expose them to STEM [20]–[22]. Providing early introductions to the role of creativity in engineering and the design process may also help students to feel more confident in their capabilities as problem solvers when they reach the university level.

Future Work

As stated above, the instrument project is undergoing revision. Some of the deliverables are being changed to shift the focus of the project more towards the design process itself, rather than a final product and accompanying report and presentation. On top of this, some of the criteria and constraints are being reevaluated based on the submissions from students in the first semester of implementation. To monitor the impact of the project, similar exit surveys are being employed. The wording of some questions is being revised to provide better context or clarify the intent, but the basic set of six questions is still being delivered at similar points in the semester. The authors intend to make use of this additional data to further evaluate the product and its impacts, particularly as it is further improved.

For future directions of work, similar questions should be asked of one or more of the other more traditional projects at the study institution, like the solar oven or wind turbine project. This data would provide a means for more meaningful comparison. The next step will conduct a direct comparison between these projects to better gauge how the level of engagement compares between the two. This follow-up quantitative analysis would benefit from additional data from the instrument project as well and may serve as a direction for future study to follow up on this exploratory work.

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