The Artistic Identities of First-Year Engineering Students

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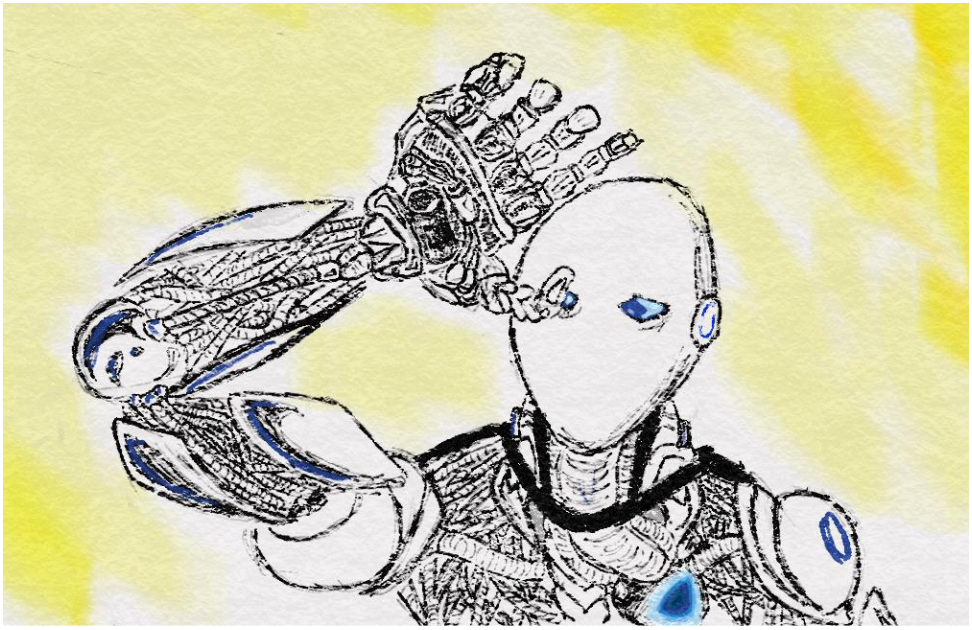


Introduction

How might artistic identities fit in with those of engineering? This exploratory study begins to unpack characteristics of first-year engineering students and their artistic identities. The first two years of undergraduate engineering education are composed of science and math courses that drive a monodisciplinary method of instruction. The dominance of single-subject classes steers learning away from creative problem solving towards close-ended, well-structured problems. Coupled with the heavy workload and time constraints, students lose the opportunity and will to supplement their learning with subjects that may not fit their major. Students lose the drive to take risks. One way to overcome the monodisciplinary comforts is for instructors to begin incorporating teaching practices from other disciplines into their seemingly siloed classes.

This study explores a first-year introduction to spatial visualization class taught to engineering students as "training to improve three-dimensional visualization skills" [1]. The professor's innovative instruction included creative ways of learning which targeted students' spatial reasoning skills. Through the semester, students practiced freehand sketching, learned Computer Aided Design (CAD), designed for additive manufacture, and created 3D printed tangible objects. The instructor consistently encouraged the students to freehand sketch objects, as a way to enhance their ability to see the physical environment and improve their spatial visualization skills. The instructor employed various exercises throughout the semester to challenge the students to think creatively to let their artistic talent shine as well as aiming to instill confidence in their freehand sketching abilities. Because artistic and engineering skills are often seen as distinct, challenging students who do not identify as artistic or creative to begin flexing their creative muscles can be rather difficult. For classes that require creative thought, it becomes imperative for students to first, realize that creative practices and artistic endeavors are possible

and even necessary to be successful in engineering and are not just for aesthetic appeal. Second, students may not view creativity as a trait that can be enhanced so it can be necessary to redefine creativity in students' minds such that it is regarded as malleable something that can be learned. The concept may be difficult for students to grasp fully and can result in a more challenging prerequisite than the actual class instruction itself. However, altering students' mindsets on what can be learned and improved is a crucial element to their development in becoming confident life-long learners. Without diverse educational practices, students cannot benefit from the multitude of learning opportunities they will encounter in and out of the classroom.

Review of Literature

Through the acknowledgment that intelligence can be increased, we maintain that creativity falls under the incremental theory of intelligence in that creativity can be increased and that engineering and creativity can be taught together [2], [3]. However, in the current engineering culture, an artistic identity falls outside of such an understanding and can be the cause for students to distance themselves from engineering because it ostensibly lacks space for artistic thought. As an example, an interviewee in Matusovich, Streveler, & Miller, (2010), is an engineering student who identifies as an artist, but only sees a future in engineering as career safety, rather than an area in which to incorporate artistic skill. [4]. Students may need to be taught how to integrate these two qualities and potential identities to use them to their full effect. In the way that creativity and science are seen to have more in common, engineering and creativity also need to be brought closer together.

The notion of 'creative scientists' is prevalent through media to a far greater extent than those who are considered creative engineers. The western cultural icon of a 'mad scientist' relies on a sense of creativity embedded in the scientist's passion that ultimately drives them mad. Robert-Root-Berstein, Allen, Beach, et al. (2008) show that Nobel Laureates in the sciences were three times more likely to have had artistic endeavors than their counterparts [5]. When unpacking the intersection of engineering and art, we have a more difficult time linking art to engineering as concretely as we do with art and science. Perhaps this difficulty is due to the integral role emotion plays in enhancing creativity [6], yet since the idea of incorporating emotion and the resulting vulnerability into engineering classes falls on hesitant shoulders, a gap remains between the arts and engineering [7].

Emotion has been taken out of engineering education, which in part drives the need to "re-humanize" engineering through multiple perspectives and diverse thought [8]. Dym et al., (2003) expand further by identifying the importance of reframing problems in engineering design. By focusing on the non-technical complexity of the problem, students learn not to oversimplify problems, but to design with social, ethical, and multi-disciplinary concerns in mind [8]. Encouraging students to flex their creative skill within their respective classes, rather than solely through sparse elective requirements is vital to enhance their approach problems such that it includes a multitude of perspectives. Framing a problem can often be the most difficult part of the engineering design process, and for that, it requires the use of creative alternatives that are not just thought of by the 'creative' students of the class, but by students trained to think and work creatively [9].

By focusing on the problem and fleshing out the intricacies that it may hold, students are encouraged to explore multiple perspectives, which is commonplace in art education but still requires explication in an engineering learning environment [10]. Art in engineering is more than making the work 'aesthetically pleasing' and more than a marketing tool. It is a way to expand how students think about the problem and the process. Through an arts education, the focus becomes the problem rather than looking for solutions before understanding the problem. More often than not, this process results in the reduction of detail and attempts at a holistic understanding of what the problem entails. Recent literature has shown how important it is to shift more of a focus to the framing and reframing of a problem over diving directly into a solution. With an understanding of how the design process is implemented in art education and other disciplines, we can improve fields through an interdisciplinary approach to design. One instance of cross-disciplinary education is offered through STEM plus the arts (STEAM), which is instrumental in the diversification of students and student thought in engineering.

The rising interest in STEAM is partly because of how seemingly dissimilar the fields of STEM and the arts are and how their distinctiveness has been used as a tool to diversify prospective STEM students, by supplementing STEM with art education. However, instead of using the arts as a means to draw diverse students to the field, the incorporation of an arts education could be used to expand the perspectives of those in engineering education. Engineering students bring a level of creativity to their respective programs that may not always be seen as creativity. There is a need to harness existing student creativity and enhance it rather than to "extinguish the sparks of creativity [the] students bring with them" [11]. Guyotte posits that the arts challenge us to think critically about the beliefs we hold about ourselves and about the world in which we live [10]. As engineering education includes more ill-structured, real-world problems, efforts to help engineering students think more critically also need to grow and diversify [12]. The introduction of art education methodologies in engineering education may offer a potential solution towards these efforts.

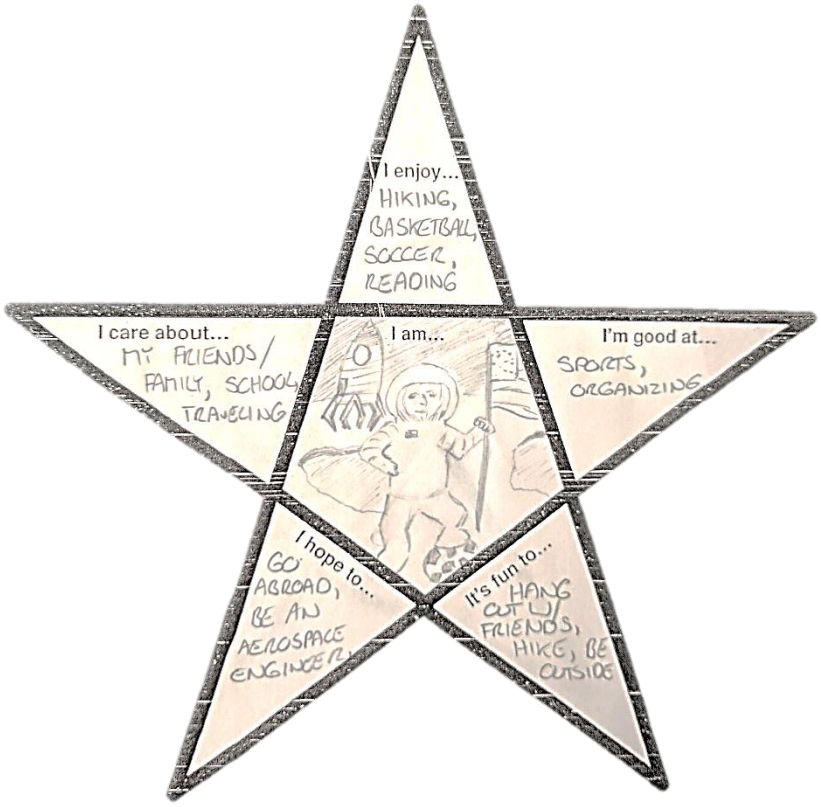
In a sense, different types of sketching can act as a form of framing and re-framing a problem. Sketching can be called a physical form of multiple perspectives, one in which the same object is viewed from different sides to represent the overall object. Consequently, sketching remains a crucial part of the design process, for it acts as a form of collaborative communication as well as a way to highlight issues that can be difficult to find initially [13]. There are different purposes for sketching, ranging from technical sketches to free-hand sketching used as a means of brainstorming and idea generation [14]. For students, transforming their sketching ability requires practice and confidence such that they use it as a means to an end rather than as an end in itself. Unfortunately, the misconception that artistic ability is a fixed trait is persistent among many people, which poses a greater challenge in teaching to improve creativity because it becomes necessary first to teach that students that creativity *can* be improved [2], [3].

Methods

The spatial visualization class taught to first year engineering students consisted of 169 students, of which 92 were male, and 77 were female. The female to male ratio was much greater than that of an average engineering class at almost 46% female students. As to how this may have affected the class dynamic was left unmeasured, however, it was interesting to be able to group across

women and have that quantity be larger than the U.S. average 18-20% of women who graduate with undergraduate engineering degrees [15].

Figure 1. 5-piont star with five prompts



We administered the survey in the format of a 5-point star where each point asked the student to write in their endings to five prompts; ‘I enjoy,' ‘I care about,' ‘I am good at,' ‘I hope to,' and ‘it’s fun to.' An example of the star questionnaire is shown in Figure 1. The questions were designed to allow the students to present themselves with an open-ended and reflexive exercise. The aim of this questionnaire was not to specifically answer questions but to understand the class as a whole on their hobbies, skills, and aspirations. The same questions were posed at the end of the semester as an addendum to students’ final report which was in standard report form. The format of the questions and setting in which students responded were different. Thus we do not attribute the differences to any one factor, as this is not a goal of the study. Additionally, the students were first-year engineering students, so they answered the first questionnaire only a week into their entire college experience, which confounds potential conclusions even further. Consequently, we do not attempt to argue that the spatial visualization class had major impacts on the students’ altered responses to the questionnaire.

Regarding uncovering artistic profiles of the class, we posed the question of whether the students considered themselves to be artistic. Because of the self-identifying nature of this question, we were able to glean a sense of the confidence and assuredness of their responses. Granted, the notion of ‘being artistic’ is highly subjective and will differ across varying interpretations of

what artistic truly means. However, because an indirect aim of this class was to expand the idea that creativity can be increased through practice, the question was sufficient in collecting the appropriate data for it allowed the researchers to see which students were comfortable in identifying as artistic. From these results, we were able to further discern characteristics of the 'artistic' students from their answers to the previous star questionnaire both from the start and end of the semester.

In addition to the survey questions, the students also were tasked with a reflection on the process of designing a Christmas ornament through sketching and then with CAD, which resulted in 3D printed physical objects. The open-ended reflections shed light on how the students approached the process of design and what they wish they had focused on more. Through this study, we aimed to gather a better understanding of the artistic profiles of first-year engineering students and will address the following research questions:

- RQ1*: What are the artistic profiles of upcoming first-year engineering students?*
- RQ2*: How do the artistic engineering students differ based on gender?*

Data and Results

The introduction to spatial visualization class with first-year engineering students (N=169) had almost an equal representation across genders, of which 77 were female students. For the question of whether or not the students considered themselves artistic, 16 students said yes (4 male and 12 female), 17 said they were somewhat artistic (4 male and 13 female), and 136 answered that they do not consider themselves artistic. Nine of those who answered "no" went so far as to say "Not at all," with seven male and two female respondents. In a class where the slight majority is male, the majority of those who answered as identifying as at least somewhat artistic was significantly female with 25 out of 33. Table 1 below presents the distribution by gender for the "artist" student self-perception.

Table 1. Students Responses to Artistic Question

Artistic	***Yes/Somewhat***	***No/Not at All***	**Total**
Female	25	52	77
Male	8	84	92
Total	33	136	169

Students' gender and artistic identity, as artistic and somewhat artistic, were significantly correlated, 0.299, $p < 0.05$. Gender and those who answered "not at all artistic" had a non-significant correlation of 0.111 (p = n.s). Due to the exploratory nature of this study, increasing this sample size would yield a better understanding of how different gender attitudes are to embrace an artistic identity, as well as offer more samples that identified fully as artistic rather than combining with those who identified as somewhat artistic. The five-question survey responses of the students who identified as artistic are in Table 2.

Table 2. Artistic Students' Responses to 5-Question Questionnaire

Enjoy	**Care About**	**Good At**	**Hope to**	**Fun to**
Reading 14.3%	Family 30.8%	Art 16%	Success 24%	Friends 24%
Having Fun 10.7%	Friends 30.8%	STEM classes 12%	Humanitarian Efforts 20% *(100% female)*	Art 12%
Friends 10.7%				
Art 7.1%	Humanitarian 15.4% *(80% female)*	Sports 12%	Having Fun 12%	Travel 12%
Education 7.1%	Education 7.7%	Video Games 12% *(75% male)*		Video Games 8%

One notable finding was that only women responded that they would want to work in humanitarian efforts in the future. Moreover, the group who identified as artistic had a 20% response rate for pursuing humanitarian work, which is greater than that of the entire class which had a 15% response rate for humanitarian work. Perhaps this is because there is a much greater sample of women in the artistic group than in the overall class size. Further data is necessary to understand the relationship between gender, artistic identity and hopes to pursue humanitarian efforts.

To gather a better understanding of the 33 students who said they were somewhat artistic, we gathered evidence from their reflections. In this group, one of our assumptions had initially been to assume that the artistic question they answered referred to a talent or interest in the fine arts. In one of the students' reflections, they refer to themselves as a "*less than adequate artist*" with thoughts on how they would not "*be able to succeed in a class where sketching had so much weighting*." This student went on to say that once they realized their "*grade wasn't based on how good of a drawer*" their confidence in success surfaced and they were able to focus on their free hand sketching as a means of improvement rather than as a way to be graded.

Many students focused on the realization that with spatial visualization skills they learned to see problems differently. One student said how the class taught them how to "*break down a problem into multiple steps and look at it from every angle, in the most literal sense*." Another student explained how having multiple viewpoints was useful "*to picture each of the different sides of an object in [their] head if given only one image of the object*," which they then tied into an understanding that the use of multiple viewpoints is necessary from a figurative standpoint as well.

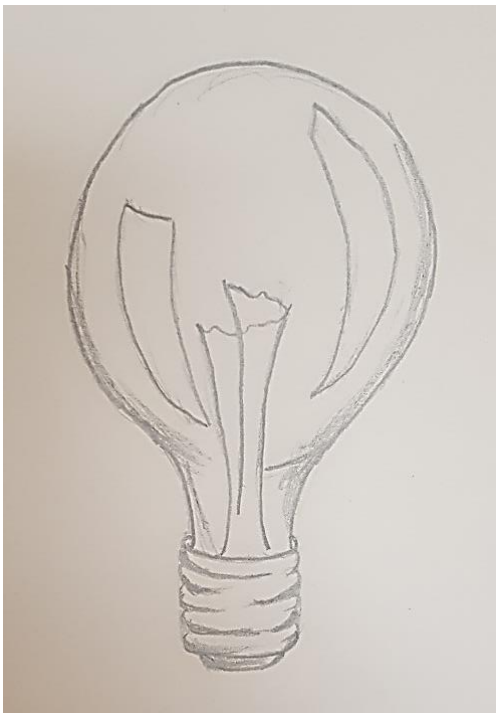


Figure 2. Sketch by student as a self-reflection

The students also offered insights of how to transfer what they learned in the class to problems that reach out of it. For example, one student said:
"Take the problem in parts, don't focus on the whole. That is really the basics of it. If you focus on the whole, it's overwhelming, so take it in parts."

Where another student stated that this "*new method of thinking,"* referring to design thinking, "*has allowed me to remain calm and think through problems in a reasonable manner*." The reflections also demonstrate an understanding that problem-solving is a large part of what it means to be an engineer. Students maintained that the skills they learned in this class would be beneficial to their work in other classes and ultimately *"for becoming more professional, wide thinking engineers."* Additionally, many of the students reflected on the sketching exercises from an improvement standpoint, in that they saw the merit in sketching for their futures. The realization that sketching was not just a means of producing a product, but also as a tool to use in the future.

"*I find that sketching will help me the most in the future. Sketching is the brainstorming part of writing an essay. You don't go into an essay without having an idea whether in your head or on paper. The same goes for designing something. You must have an idea of what you want to create and sketching is the way to get that idea down and also allows you to share your ideas with others for critiquing."*

The understanding that sketching itself is a way of thinking was very important for students to realize so they could begin using it as a tool rather than as something to perfect by showing to their peers or instructor. Many students noted how they regretted not having more sketches leading up to their final design project, which further underlines the newfound importance they placed on sketching as a tool to improve their end-product.

Discussion

The exploratory nature of this study supplied a platform from which to narrow down the scope of the research design and gather more data on the preliminary relationships of these findings. The questions of whether artistic identities conflict with those in engineering, still necessitate further

inquiry, especially to determine if engineering does not attract artistic individuals or if it reduces the learning space for artistic skill.

One of the most prominent findings in the survey questions was that of the 33 first-year engineering students who said "yes" or "somewhat" to the question asking if they consider themselves artistic, 25 of those were female. This finding raises the question of if women are more inclined to consider themselves artistic because of underlying notions that women are better at art and thus are more artistic or if it is because male students are less confident in calling themselves artistic due to a singular acceptance of what being artistic means.

In efforts to dissect what was understood by the *artistic* students, future studies could benefit from looking into what students define as the attributes of an artistic identity. The first-year engineers' perception of an artistic identity may highlight unforeseen similarities with an engineering identity that first-year students may have yet to adopt. The question of artistic identity was administered at the end of the semester and students self-reported, suggesting that the responses not be necessarily a transferable or comparable attribute outside of this learning environment. Nevertheless, the question may be more revealing of students' artistic confidence which in fact is equally if not more relevant to one's artistic identity. Consequently, from these findings, we find it necessary to explore the relationship between confidence, artistic identity, and perceptions of an artistic identity.

The responses students had to the end of semester questions were varied, in which the largest percentage was never more than roughly 30% of the "artistic" students. Those who identified as

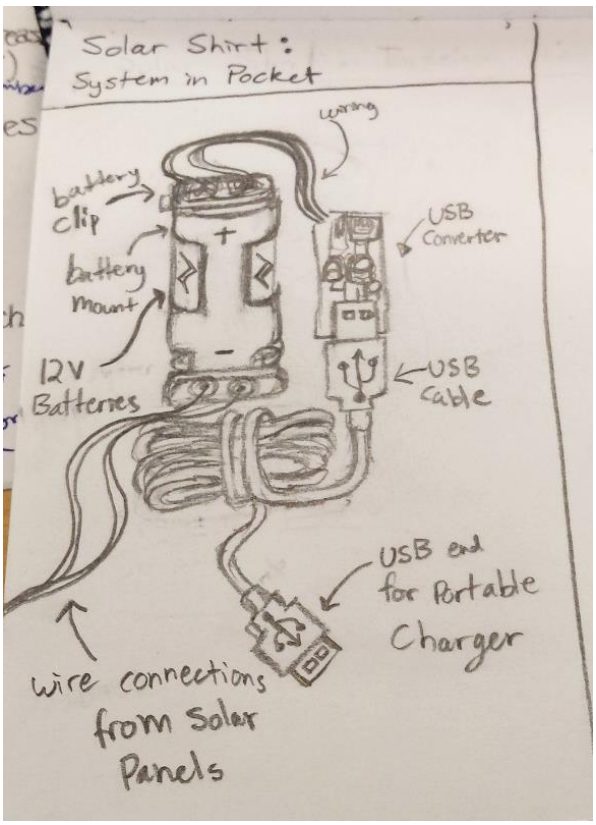


Figure 3. Sketch by student for free-hand practice

Figure 4. Sketch by student of self-reflection

artistic said they either hoped to work in or cared about humanitarian efforts, of which the majority were female. The relationship students see between engineering, and their environment (physical and social) might be more of a driver for female students to pursue engineering. With that said, art education also takes into account the relationship between the artist and their environment so perhaps the draw to humanitarian efforts is not necessarily a gendered correlation but that of having an affinity for the arts. The nature of this exploratory data offers fertile starting points to develop more specific research questions about the relationship between artistic identities of engineers about their aspirations towards humanitarian work.

Implications for Engineering Education

Through this exploratory study, we raise concerns about whether having an artistic identity conflicts with the aspiration to pursue engineering. By identifying the characteristics of each, we find that there is value in establishing common ground between the arts and engineering, rather than widening this academically constructed gap.

Overall, women identified more as artistic, which may signify how to improve efforts in their retention in engineering. By opening space for engineering students to express and enhance creative skill, we can indirectly diversify engineering education. Rather than just trying to attract the *creatives* to engineering, we should focus more effort on instilling creative confidence in our students by including spaces that are risk-tolerant and rewarding of creativity. It is not that students who are attracted to and persist in engineering are *not* creative, it is by our instruction that creativity is neglected and then phased out. Enhancing the creative skills of engineering students can begin by incorporating the practices of art education, not necessarily to reconstruct engineering courses, but to pepper our existing courses with material borrowed from the more colorful side of campus.

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