# WIP: Developing an arts-informed approach to understand students' perceptions of engineering

Homero Murzi
*Department of Engineering Education*
*Virginia Polytechnic Institute and State University*
Blacksburg, United States
hmurzi@vt.edu

Diana Franco Duran
*Department of Engineering Systems and Environment*
*University of Virginia*
Charlottesville, United States
dmf8a@virginia.edu

Jason Forsyth
*Department of Engineering*
*James Madison University*
Harrisonburg, United States
forsy2jb@jmu.edu

Karen Martinez Soto
*Department of Engineering Education*
*Virginia Polytechnic Institute and State University*
Blacksburg, United States
kmartinezsoto@vt.edu

Matthew James
*Department of Engineering Education*
*Virginia Polytechnic Institute and State University*
Blacksburg, United States
mjames@vt.edu

Lisa Schibelius
*Department of Engineering Education*
*Virginia Polytechnic Institute and State University*
Blacksburg, United States
lisaschib@vt.edu

***Abstract*—This work in progress paper describes preliminary results of a methodology used at three different universities to explore students' perceptions of engineering through drawings. One of the primary objectives of introductory and foundational engineering courses is to help students develop a sense of identity and belonging within the field of engineering, and understand basic engineering knowledge and skills. Hence, it is crucial to understand students' preconceptions of the engineering discipline when they start their academic program. However, many students entering the program have narrow preconceptions or limited knowledge about the field. One challenge instructors face is how to facilitate students' thinking about their own perceptions of engineering in a meaningful way. A typical activity to help the students understand their perceptions of the engineering discipline is to ask them, "What is engineering?" However, instructors have been frustrated by the lack of depth in students' responses. This paper explores a different methodology to understand students' perceptions of the engineering discipline by taking an arts-informed approach; instead of writing down their perceptions or talking with a peer, students are first asked to draw a response to the question "What is engineering?" Data were collected and analyzed using an arts-based open-coding approach. Initial results provide a representation of students' preconceptions about the discipline in terms of human, technical, process-based, and holistic/global aspects, which provide further evidence that arts-based methods are effective in capturing student deep perceptions of the engineering discipline.**

***Keywords—engineering identity, arts-informed methods, drawings, first-year engineering***

## I. Introduction

Engineering identity has been used as a crucial lens to understand how engineering students develop their competencies and professional path to become (and feel) engineers. Several studies have used engineering identity as a framework to conduct work around recruitment and retention in engineering [1]–[4]. However, engineering identity is usually studied using survey data and interviews. Although valid to capture some of the students' experiences, it does not provide the full picture, especially when trying to understand if institutional characteristics and foundational engineering courses' structures influence identity development early in the engineering program.

One of the primary objectives of introductory and foundational engineering courses is to help students develop such sense of identity within the field of engineering as well as understand basic engineering knowledge and skills, which in turn will support them in their selection of an engineering major and ultimately in their persistence toward their selected degree [5]–[9]. Hence, the importance of not only understanding engineering identity development (i.e., what students believe "engineering" to be and whether they view themselves as belonging to that ideal, profession, or educational program [10]) but also understanding what preconceptions they might have in those ideas. Identity and belonging are essential as students that engage with engineering activities, develop social networks [11], and feel accepted in that identity [12], [13] are more likely to persist in their engineering program. Therefore, understanding students' preconceptions of the engineering discipline when they start their academic program is important. However, many students entering the program have narrow preconceptions or limited knowledge about the profession. One challenge instructors face is how to facilitate students' thinking about their own perceptions of engineering in a meaningful way. Although a typical activity to help students understand their perceptions of the engineering discipline is to ask them, "What is engineering?" instructors have been frustrated by the lack of depth in students' responses. This paper explores a different methodology to explore students' perceptions of the engineering discipline by taking an arts-informed approach. Instead of writing down their perceptions or talking with a peer, students are asked to draw a response to the question "What is engineering?"

The purpose of this Work In Progress paper is to present the codebook created after the initial analysis of our data. We consider it essential to provide some of our initial outcomes in the process to analyze data and report on our initial codebook as it can be helpful for researchers interested in replicating this methodological approach.

## II. Prior work

As mentioned, research in engineering education has focused on understanding engineering identity primarily by understanding the perceptions undergraduate, middle school, and high school students have about engineering [14]–[18]. The main issue with these studies is that they have used traditional methods to ask the students to self-report their perceptions, an approach that, although valid, might not provide the whole picture. We decided to take an alternative approach. We propose an arts-based method to capture student perceptions of engineering using drawings. For this study, we asked first-year engineering students to draw a visual response to the prompt: "What is Engineering?".

Arts-based approaches have been used before in engineering education research. For example, Capobianco et al. [19] used the Draw-an-Engineer Test and asked 400 elementary school students to draw an engineer doing engineering work. The authors analyzed the data using content analysis and statistical testing and identified that students described engineers as mechanics, laborers, and technicians. They also identified engineering work as fixing, building, making, and using vehicles, engines, and tools. Capobianco et al. identified that most of their participants identified engineers as men [19]. Although they developed a framework for organizing and interpreting students' conceptions of what an engineer is, we consider that the framework is missing capturing students' understanding of engineering as a field beyond the personification of the engineer.

Similarly, Ganesh et al. [20] used the Draw-an-Engineer Test to collect data from Junior High-School students enrolled in a program that developed several engagement activities. The goal was to understand individual perceptions of engineers. They administered the test as a pre-and-post intervention at the beginning and the end of the academic year. The three main emergent themes were engineers in action, the occurrence of gender, and engineers' clothing. Similar to Capobianco et al. [19], Ganesh et al. [20] found that students had a lot of preconceived notions about associating engineers with men. However, this type of thinking shifted at the end of the academic year. This study also lacks to present students' perceptions of engineering as a discipline, and both studies are also not focused on undergraduate engineering students.

Although arts-based approaches have been used in higher education literature [21]–[23], less research has been conducted on first-year engineering students. One study done in this space was through the work of Ozkan et al. [24]. In their research, the authors studied first-year engineering students' perceptions of themselves using pre-and-post drawings. Students enrolled in a spatial visualization class were asked to sketch themselves at the beginning and end of the semester to identify the differences in their perceptions. The authors' analysis yielded data around four main themes, nature-identity, institution-identity, discourse-identity, and affinity-identity. Although this work provided a good perspective on how students perceive themselves and validated some of the aspects we are interested in understanding (e.g., institutional differences), the study was not focused on understanding the engineering discipline or identity.

Nevertheless, we consider using an arts-based approach a valid methodology to more fully understand how first-year engineering students enrolled in different foundational engineering courses at other institutions perceive engineering as a discipline and how those perceptions change over time.

## III. Institutional context

As mentioned, we decided to explore three different institutions in the state of Virginia that have different approaches to the way that engineering students are trained. Our overarching goal in this work aims to understand if institutional differences play a role in how students perceive and develop their engineering identity. The context of the courses at each institution is as follows:

### *A. Virginia Tech (VT)*

The purpose of the Foundations of Engineering courses is to welcome all incoming engineering students, to instill a sense of belonging and identification with engineering to support long-term persistence toward a degree, to introduce them to the engineering discipline, to help them select their engineering major from among more than 14 options, and to provide foundational academic, technical, and professional knowledge and skills needed to succeed in that major. The two-credit courses each serve more than 2,200 students per year. To accomplish our goals, the sequence includes team-based and individual activities, assignments, and projects that place students in situations to design and scope ethical and holistic solutions to ill-structured engineering problems using a standard set of fundamental engineering tools that are applicable across a wide range of majors, including basic computer programming and computer-aided design (CAD).

### *B. James Madison University(JMU)*

Engineering Decisions is the first required course in the Engineering major. It focuses on evidence-based decision-making and analysis in a variety of engineering fields. As the JMU Engineering Department is multi-disciplinary, topics are covered from various perspectives to provide students with a holistic engineering perspective. Tools training in both the physical shop and the maker space are covered, as well as exposure to modern software tools, such as MATLAB. Additional topics include hand sketches, engineering drawings, ethics, and presentation techniques. The typical enrollment each semester is approximately 150 students.

### *C. University of Virginia (UVA)*

The Introduction to Engineering course aims to provide an overview of the engineering profession and the disciplines and functions within engineering. It introduces students to engineering design and the role of creativity in solving open-ended (design) problems. The conceptual understanding and skills needed to apply the engineering method are integrated into a significant, hands-on case study project. This project, intended to be both fun and challenging, focuses on a realistic problem,

requiring a balance of engineering analysis and the economic, cultural, political, and other considerations needed to achieve a successful solution. In addition to the fundamental role of engineering analysis and optimization, students develop computer skills using spreadsheet and math solver applications and apply these to engineering problem-solving. The four-credit course serves more than 650 students per year. Students engage in both individual and teamwork and consider the contexts in which engineering challenges arise.

## IV. METHODS

This WIP presents the overview of the codebook created after initial data analysis of our preliminary data. Our work intends to explore the students' perceptions of engineering and how they relate to their identity development during their FYE courses. We will account for institutional differences and different settings in the courses. This is part of a larger project that poses the following research questions:

a. What are first-year engineering students' perceptions of engineering before starting their program?

b. What are first-year engineering students' perceptions of engineering after their first engineering course?

c. How does institutional context (e.g., program size, curricular structure, type of instruction, course content, geographical location) affect identity development in first-year engineering courses (questions a & b)?

We collected students' drawings responding to the question "What is engineering?" at the beginning (pre) and the end (post) of their introductory FYE course at the three study institutions. The research design is a qualitative arts-informed visual method design. Data has been analyzed using the Qualitative academic software NVivo. The codebook has been developed with initial pre-data that includes about 400 drawings from students. The patterns presented in the codebook will develop emerging themes that will allow us not only to understand the different findings from the data but also understand any potential changes (pre and post-analysis), and account for institutional differences.

## V. PRELIMINARY ANALYIS – THE CODEBOOK

The main goal of this WIP is to present the codebook that will be used for data analysis of our data. After going through an initial process of analysis, our codebook is presented in Appendix A. We started our work by identifying and labeling the different aspects that could be seen in the drawings. For example, a common theme was the ***Human*** aspect. This included not only when people were included as part of the drawing but also expanded to other human aspects, for example, many drawings were showing the importance of teamwork and collaboration, or included different emotions. Some drawings also included gender perceptions that students could have (for example, that engineering is men dominated). We also included in this theme aspects related to the brain. Figure 1 is an example of the Human theme.

The second theme is focused on ***Technical*** aspects (Figure 1, part 2). In this theme, we included parts of the drawings where students had things (concrete objects) related to technical aspects of engineering, including tools, gears, bridges, buildings, etc. This theme represented a big majority of the drawings as students pre-conceptions of engineering appear to be very focused on the technical aspects.

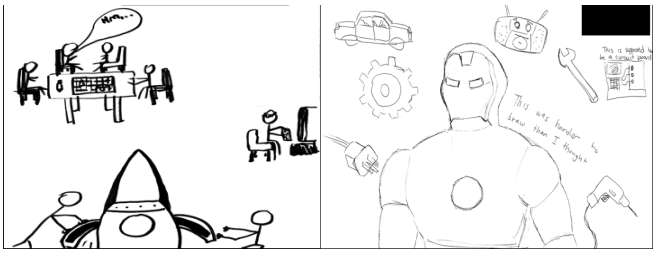

Fig. 1. Example of the Human & Technical theme

The third theme (Figure 2) includes aspects of the drawings that focused on ***processes***. This theme had two main categories, one was related to the process itself where students draw a full or partial process, and the second part was related to the outcome of final product out of that process. We decided to establish that difference because in some cases students when focusing on a process did not have a clear outcome.

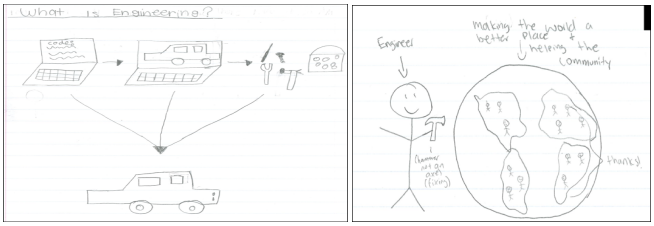


Fig. 2. Example of the Process-based & Holistic-global theme

The final theme was about ***holistic/global*** aspects (Figure 2 part 2) where students presented issues related to the social and broader impact of engineering, like the impact of engineering in the world, in solving some of the worlds' problems, in showing engineering for the greater good, or just in showing an understanding that engineering can have a purpose that goes beyond the technical aspects of the discipline.

## VI. CONCLUSION

This WIP presents the overview of the codebook created after the initial data analysis of our preliminary data. Our future work includes extensive analysis of all the drawings (2000+) that will provide us with a different perspective on how first-year engineering students perceive the engineering discipline and try to identify if those perceptions are influenced by institutional differences.

## ACKNOWLEDGMENT

This material is based upon work supported by a 4-VA Advancing the Commonwealth Collaborative Grant. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the agency.

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## APPENDIX A. CODEBOOK

| **Codebook** | | |
|---|---|---|
| ***Theme*** | ***Codes*** | ***Definition*** |
| Human | Brain | “Human” refers to visuals that have a human representation. These drawings include people or a representation of human things like collaboration or emotions |
| | Change in Emotions | |
| | Gender perceptions | |
| | Collaboration/ Teamwork | |
| | Includes People | |
| | Identification with leadership and or power dynamics | |
| | Negative Emotions | |
| Technical | Bridge | “Technical” refers to the inclusion of depictions representing the technical aspect of the engineering discipline. This theme includes students’ representations of many different technical aspects, from math and equations to rockets and planes |
| | Buildings | |
| | Cars | |
| | Gears | |
| | Hand Tools | |
| | Math | |
| | Planes | |
| | Rockets | |
| | Use of Technology | |
| Process-Based | Outcomes | This theme refers to students’ representations of a process rather than an individual thing. It involves sequential steps or the final goal represented by a clear expectation or achievement of solving a problem |
| | Processes | |
| Holistic & Global | Earth/Globe | In this theme, students took a holistic approach to the discipline, usually in terms of attempting to solve the world problems, or there was a clear representation of holistic issues affecting the discipline |
| | Holistic Issues | |