

## **Characterizing Identity Profiles for Engineering Students Attending Small Colleges and Universities**

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## **Title:** Characterizing Identity Profiles for Engineering Students Attending Small Colleges and Universities

### **Abstract**

Small schools often boast that their value lies in personalized education, experienced teachers, and engagement opportunities. In 2017, about 52,000 of the graduating engineering students came from small colleges and universities. While representing a small fraction of the total number of graduating engineers each year, these students may be significantly different than their peers trained at larger schools if the claims made by small schools are correct. This paper presents common identities of students who attend small colleges and the impact of the small school environment on those identities. Interviews were conducted with N=24 undergraduate engineering students from four small schools: a religiously affiliated school balanced between liberal arts and engineering majors, two technical schools with predominately engineering majors, and a non-affiliated liberal arts school where engineering majors were a minority. After the interview, participants could take a survey to outline and rank identities that they felt applied to them. This study used the Model for Multiple Dimension of Identity (MMDI) as a framework to interpret and visualize the identity rankings. Results show that the type of small school significantly impacts the prominent identities of its students. Schools where engineering students were a small portion of the campus population supported multiple students' identities beyond identifying with their major. Women were also more likely to believe that their school environment significantly impacted which identities were more prominent regardless of school type. While each individual is unique, recognizing the archetypes of prominent identities can increase our understanding of the type of students who attend small schools and open the door for tailored instruction that capitalizes on these identities in a school's population.

### **Introduction and Literature Review**

The engineering education research community has struggled to agree on precisely what "engineering identity" is and how it is measured. Instead, many varying (but often complementary) definitions are proposed [1]. Direct assessments of engineering identity can be as simple as asking some variation of the question, "Do you see yourself as an engineer?" [2]. This straightforward approach provides an answer that can then be quickly correlated with demographic information or academic performance. Another approach associates engineering identity with recognition, interest, performance, and competence in subjects relating to engineering (i.e., physics, math, and science) [3]–[5]. These models have been linked to students' likelihood of pursuing and persisting in an engineering major [6] and sense of belonging [7]. Other studies have focused on the effect of campus culture on engineering identity [8], finding that students sorted each other into social stereotypes (Greeks, academic achievers, nerds, etc.). Those labels influenced how other students saw them and how they saw themselves as engineers.

Other aspects of identity are also salient to engineering and the social and team-based environments in which engineering is typically taught. While the distribution of skillsets (both technical and non-technical) and similar social stereotypes as previously mentioned were found to influence the success of engineering teams [9], there are also gendered issues that impact women engineers [10]–[16]. For example, Ro and Knight [17] found that students' assessment of their engineering skills (leadership, professional, design, communication) differed depending on

gender. The same study found that instructional methods and co-curricular experiences also influenced engineering skills, but gender differences remained. Gill et al. [18] worked with women who were professional engineers and called for more education in the engineering space about marginalizing interactions (reminders of femaleness as an obstruction to competence, ostracization, and lack of recognition as an engineer), concluding that gender equity is a systemic issue, not an individual one.

Beyond engineering, students have many other identities that may be prominent. Those identities could be gender (e.g., man, woman, non-binary), race or ethnicity (e.g., Black, Hispanic, White), sexual orientation (e.g., hetero, LGBTQ), religion (e.g., Muslim, Christian, Hindu), or even other professional identities (military rank, athlete). Depending on the context, these identities could be more salient. However, most studies assessing the experience of engineering students focus on traditional engineering skills or aptitude [19]–[22] without considering the impact that other identities may have on the engineering experience, although some findings do indicate that gender and race are factors in attrition and persistence [23]–[31].

Outside of engineering, researchers have investigated the impacts of gender identity [32]–[36], racial identity [37]–[40], and even religious identity [41] on students' experiences in university and future career goals. These studies recognize the multiple identities that students must navigate the world with. Their experiences are complicated even further when they have multiple marginalized identities (e.g., female, people of color, and LGBTQ in a predominately White, hetero, male setting) [5], [42]–[45]. The school environment, in this case, small colleges and universities, can encourage or discourage these non-engineering identities. For instance, in religious institutions, students may feel particularly supported if their religious values align with those of the school [46]. In the same school, however, an LGBTQ student may feel like that identity must be suppressed if the religion is not supportive. Compounding these issues is the normative culture of engineering that often subliminally supports outdated ideas of who "should" be an engineer. For example, these norms may leave female students or any "othered" students feeling like they do not belong, affecting how they identify as engineers.

While limited, some work has been done focusing on small schools from an institutional level [47]–[50] as well as how a small school environment affects the students [51]–[55]. "Small" in this context refers to the Carnegie Classification of Institutions, which defines small as between 1,000 and 3,000 students enrolled. The small school environment can influence the student due to their race [56]–[58] or sexual orientation [59]. In engineering, the most relevant research lies in the community college pathway [60]–[62], small schools that offer an affordable option to start an engineering degree, often with the goal of transferring to a larger school to complete the degree. According to a National Academy of Engineering report, nearly half of engineering graduates went through community college at some point in their education [63]. Work to this end has outlined the benefits of the community college pathway for engineers. Still, it has not assessed engineering identity and how that may interact with other non-engineering identities. With little research on small schools' impact on engineering identity and, more specifically, its interaction with other predominant identities, this study seeks to address the gap. The research questions addressed in this study are

1. How do engineering undergraduate students at small universities express their various identities?
2. How do engineering undergraduate students perceive that their school influences the salience of non-engineering identities?

## **Theory**

This study's theoretical framework is the Model for Multiple Dimensions of Identity (MMDI) developed by Jones and McEwen [64]. Developed and applied predominately in psychology and higher education [65]–[68], MMDI recognizes the many interactions between multiple identities. The model argues that one identity cannot be understood without understanding its relation to the person's core identity, other external identities, and the situation's context. The core identity is the individual's personal identity and can sometimes be "protected from view" [64, p. 408]. These are the attributes, characteristics, and values that a person applies to themselves, such as "hard-worker" or "good listener." External identities are the labels that society or other people place on a person. Gender, race, sexual orientation are all examples of external identities. The model is dynamic, and the relative salience of each identity depends on the time and context. For this study, we regard engineering identity as an external identity within the context of the small college and university environment. Figure 1 is a visual representation of MMDI, referred to as the "atom model". The outermost circle represents the context (e.g., family background, sociocultural conditions, or current experiences). Each individual circle inside the context represents a different external identity the person holds. The figure is just an example of possible identities and other identities may be included or excluded depending on the person. For example, a student athlete would likely have "Athlete" as one of their external identities and someone who does not prescribe to any particular religion would not include "Religion." The overlapping of the various external identities shows the interconnectedness of the identities. The salience of each identity is represented by the dot on that circle and its relation to the core identity. If a dot is close to the core identity, then in that context, the person believes that external identity to be closely linked to their own core identity. If a dot is far from the core identity, then that external identity is not very salient in that context. For the purposes of this study, engineering identity is included as an external identity and the context is the small college and university environment.

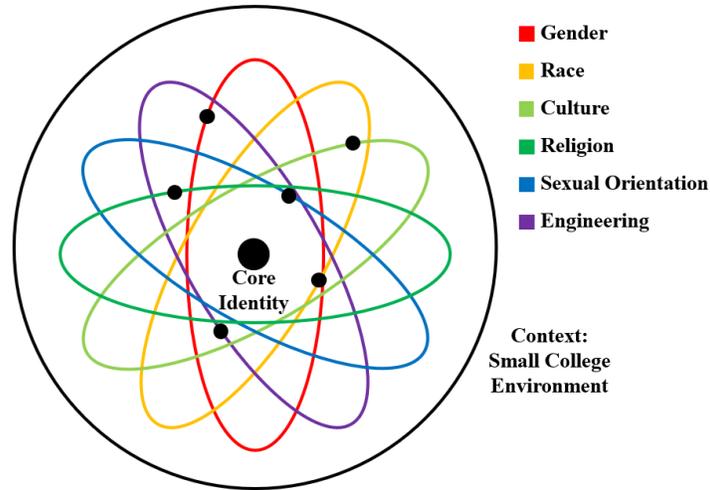


Figure 1: Model for Multiple Dimensions of Identity. Adapted from Jones and McEwen [64].

## Methods

Four small colleges and universities were targeted for recruitment. The schools were categorized as either predominately engineering majors, balanced (between engineering and non-engineering majors), and predominately non-engineering. We distributed our recruitment email to faculty and administration of engineering and computer science departments at the schools asking them to forward our survey to juniors and seniors. Those interested in participating in an interview were contacted with more information on the study and a link to schedule an interview time. Interviews lasted approximately an hour. After the interview, the participants were sent a link to an identity activity created in Qualtrics. The identity activity asked the participants to list their primary identities and then rank those identities on how important they were. We then asked how they believed their school influenced those identities and how they expressed their identities. N=24 participants completed the interview and identity activity. This study focuses on the results of the identity activity. Table 1 shows the demographic distribution of the 24 participants.

*Table 1: Demographic data of the identity activity participants*

Gender	Men	15
	Women	8
	Non-binary	1
Race and Ethnicity	White	19
	Hispanic or Latin American	3
	Native American or Native Alaskan	1
	North African	1
Year in School	Junior	13
	Senior	8
	5th year or greater	3

Table 2 outlines the type, general size, and the number of participants from each school. Identifiable information about the schools was removed to protect the identity of the participants.

*Table 2: Distribution of participants and school type for the four small colleges*

School	Type	Size	Number of student participants
"College A"	Predominantly Non-Engineering (PNE)	2,000-2,500 students enrolled	8 (1 nonbinary, 3 women, 4 men)
"College B"	Balanced/Religious (BR)	2,000-2,500 students enrolled	9 (2 women, 7 men)
"School C"	Predominantly Engineering (PE)	2,500-3,000 students enrolled	4 (1 woman, 3 men)
"Institute D"	Predominantly Engineering (PE)	1,000-1,500 students enrolled	3 (2 women, 1 man)

Participants who completed the identity activity were asked to develop between three and twelve identities that they associate with or are often associated with them by others. We provided a short list of examples, but ultimately the students created their own list of identities. Due to the open-ended nature of the prompt, a large variety of responses were given. To organize the responses for analysis, we sorted the identities into ten primary categories: Student/Learner, Major, Talents/Interests, Religion, Gender, Nationality/Culture, Class/Status, Race, Athlete, and Sexuality. Over 77% of the identity responses could be sorted into any of these categories. Some students provided multiple responses that fit into a specific category. For example, one person could submit "Dancer" and "Musician," and both would fall under Talents/Interests. Students then rated the importance of their chosen identities between 0-100, with 100 representing extremely important. Average ratings of each primary category were calculated for each school type and by gender. These average ratings were then represented visually through the atom model from MMDI.

## **Results**

### *By School Type*

Different types of schools attract different kinds of students. To see this effect at the small school level, we targeted students from two predominately engineering schools (PE), a school with predominately non-engineering majors (PNE), and a school that was balanced between engineering and non-engineering majors. The balanced school was also a religiously affiliated institution (BR). The most common identity was Major, with all but one participant including it as a response. Half of the participants (12) rated their Major as one of their most important identities. This trend persisted in the BR and PE schools. While the Major category was just as present among students at the PNE school, only one-third rated it as one of their most important identities. Only

in the PNE responses was Athlete a popular option, with another third choosing some form of Athlete as their most important identity. Other popular categories included Gender, Religion, Race, and Talents/Interests. Seventeen participants included Gender in their list of identities, but only three rated it as one of their most important. Figure 2 shows the top identities chosen by the participants by school type.

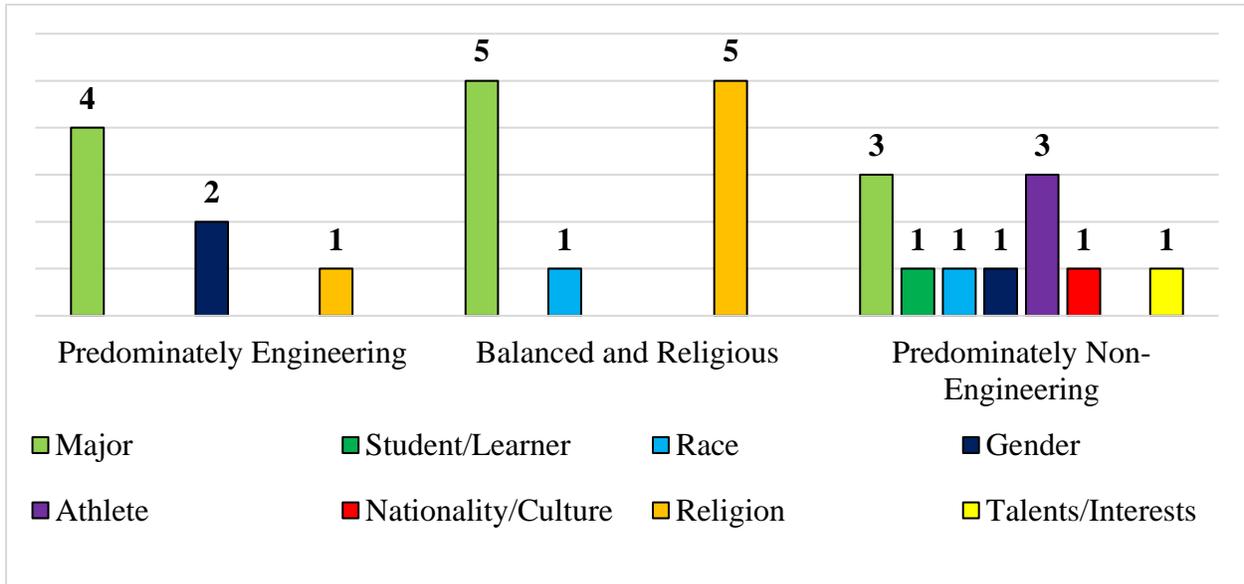


Figure 2: Top identities chosen by the participants. Participants could rate multiple identities as the same, so number of top identities may exceed the number of participants from that school type.

Most participants from PE and PNE schools believed that their school environment did have an impact on the identities they chose and how they express those identities. As part of the survey we asked participants: “Do you feel like the context of your school changes which identities you include and how they are rated? If so, how?” Figure 3 shows the distribution of responses regarding the impact of the small school environment on identity. Some students recognized how the homogeneity or diversity of their school influences which identities are more salient:

*"My school is quite homogeneous; therefore, I rated certain things that are important to me (such as cooperation) lower because there aren't many idea clashes on campus where that is needed. In the opposite sense, religion is not important to me but is important to my school's context... so I moved that to "slightly important" because I am aware of that when speaking to certain groups of people."*

-Amelia, PE

*"Yes, If I was back home my ethnicity and race wouldn't matter since everyone around me is [the same race]."*

-Zey, PNE

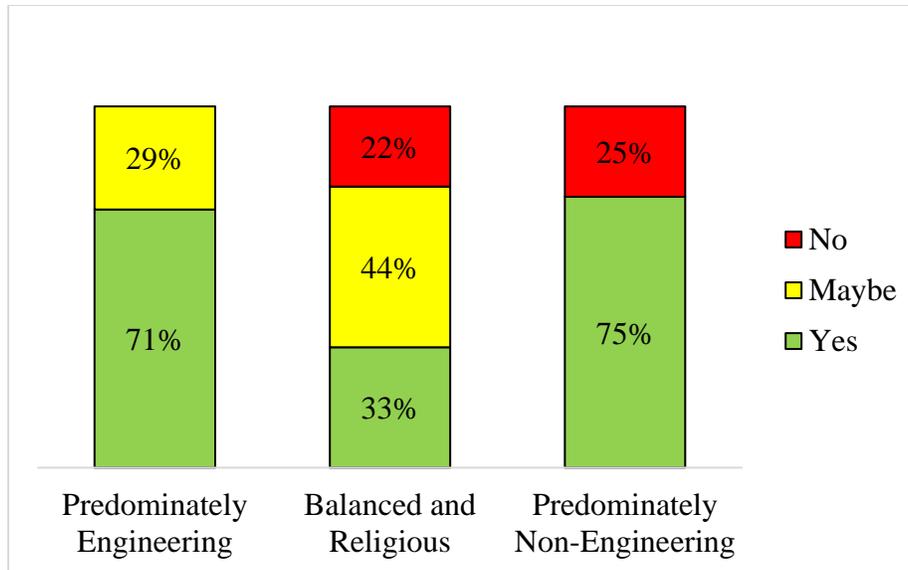


Figure 3: Distribution of responses to the question "Do you believe your school changes which identities you included and how they are rated?" based on school type.

Participants also recognized how the availability of support or resources at their school influences which identities they choose to express:

*"There are some parts of my identity I don't feel very comfortable sharing on campus (particularly my gender identity and sexual orientation). In addition, I prioritize some activities more than others, like sports over art because it's more accessible to me on campus, and it has a stronger community.*

*-Riley, PNE*

*"Yes, it allowed me to pursue my professional interests much further and faster than I would have been able to on my own."*

*-Garrett, PE*

We calculated the average value of the ten identity categories from the rating of responses from our participants and created an atom model based on the Model for Multiple Dimensions of Identity [64] from these average values. Figure 4 shows the MMDI with the top four identity categories for each school type. The closer the dot is to the center or "Core Identity," the more important that identity. Dots further away from the center represent identities that are less salient within the context provided.

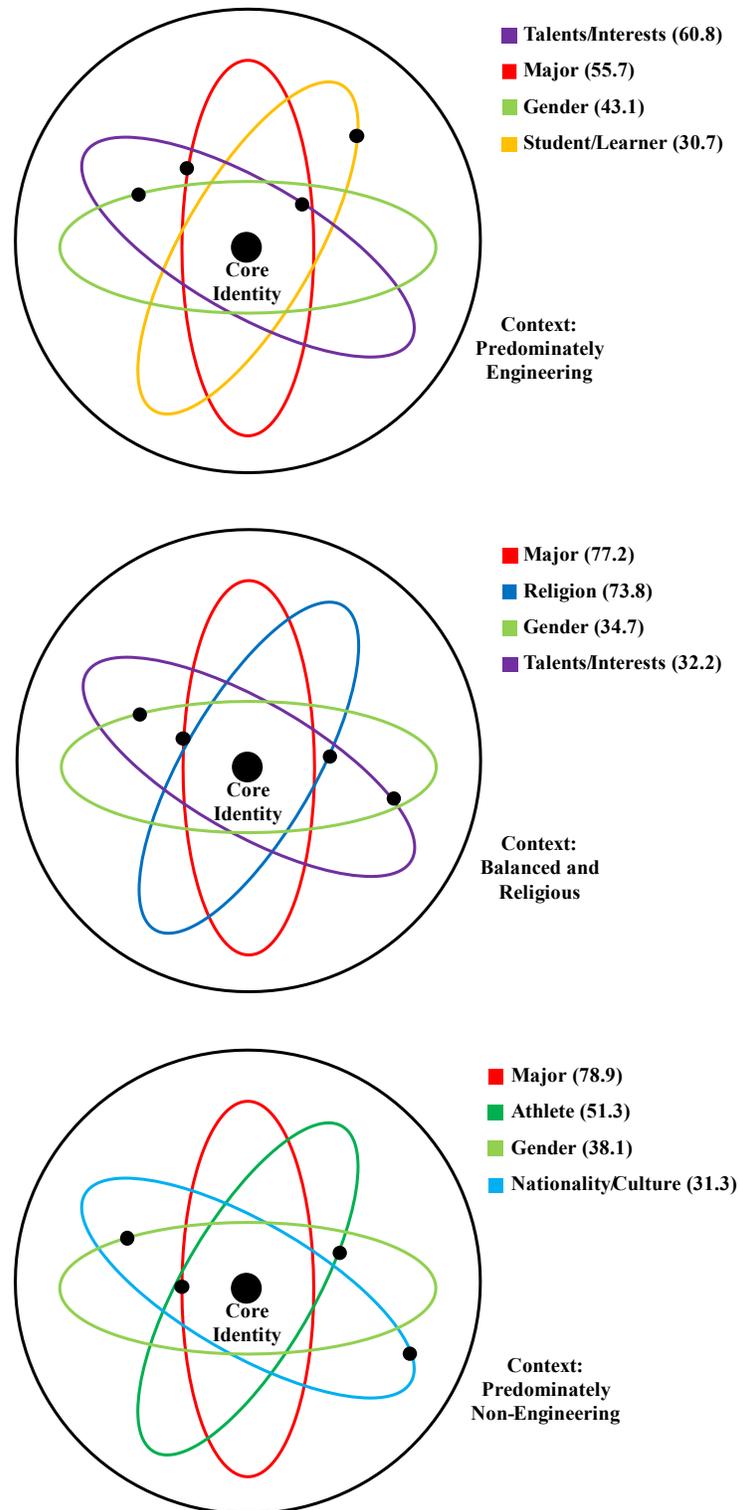


Figure 4: MMDI for predominately engineering, balanced and religious, and predominately non-engineering schools. The rings represent the top four identity categories, and relative importance relative to the core identity is represented by the orbiting dot. The average ratings (between 1-100, 100 being extremely important) are included in the legend.

Starting with the PE school model, we see that, while major is important to this group, it is not the top identity like it is with the other two school types. This initially appears counterintuitive. After all, how could a school focused on engineering not produce students with strong engineering identities? In reality, this school presents a homogenous environment where important identities do not require expression because they are commonplace. Being an engineering major in a school full of engineers is almost assumed, causing the identity to be less salient. Participants from this school did rate their identity with their major highly, but other identities were more important.

The influence on the religious affiliation of the balanced school is shown in this average MMDI model. While some participants from other schools also included religion as part of their identity, all but one participant from the BR school included it in their list. Religion and Major were the top two identities for most of the participants from this school. This tendency is understandable as the college's religious aspect is likely attractive to students who already identify strongly with that same religion. Participants mentioned growing in their faith as one of the impacts this school had on their identity, indicating that they already aligned with the school regarding religious identity.

Students at the PNE school did not include Major as their top identity as often as other participants, but that does not mean their major was unimportant to them. We see from the average model that Major still tops the list of important identities at this school, followed by Athlete, an identity category that did not make the top four in the other school types. Beyond being predominately non-engineering majors, this school also strongly encouraged its students to participate in extracurricular activities and sports. Faculty and staff were very accommodating to sports schedules, and many engineering students found time to take part in a sport. Their participation in sports offers a chance to engage and work with students outside their major. With engineering students being a minority at the school, their identity with their major is very salient, but they are forced to recognize and embrace the importance of identities outside of engineering.

### *By gender*

School type may account for some variation, but due to the gender imbalance that persists in engineering, women and nonbinary folks will have a fundamentally different experience than their male counterparts, as Anne recognized:

*“[I am a] female engineering student, which stands out more because there are less people, so it’s more noticeable.”*

*-Anne, PNE*

We reorganized our participants by gender, splitting the results of the men from the results of the women and nonbinary folks. The results of the nonbinary participant were included with the results of the women because of their similarity as underrepresented genders in engineering. In the women and nonbinary group, Gender identity was included as a response for every participant, with a third considering it as their most important identity. It only appeared in half of the men's responses, where it was never the most important identity. Race and Nationality/Culture also occurred more frequently in the women and nonbinary responses than with the men.

The women and nonbinary group participants were much more likely to believe their school environment impacted their identities. All of the study participants who thought their school does not impact how they expressed their identities were men, as shown in Figure 5.

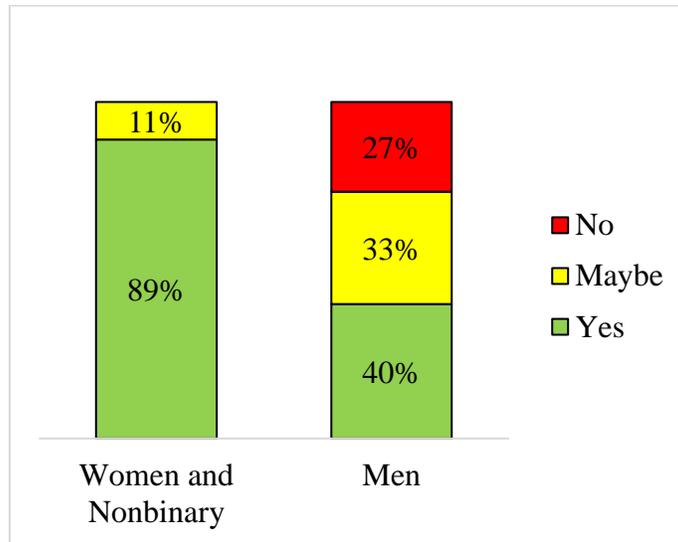
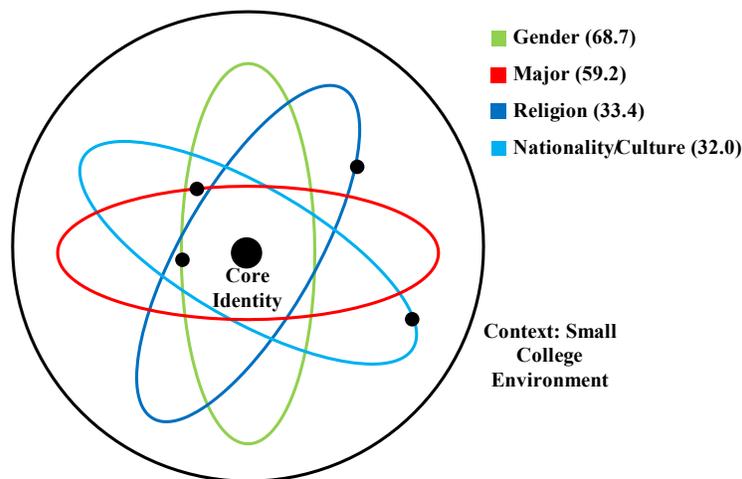


Figure 5: Distribution of responses to the question "Do you believe your school changes which identities you included and how they are rated?" based on gender.

Figure 6 presents the average MMDI for the responses based on gender. On the top are the results for women and nonbinary, and on the bottom are the results of the men.



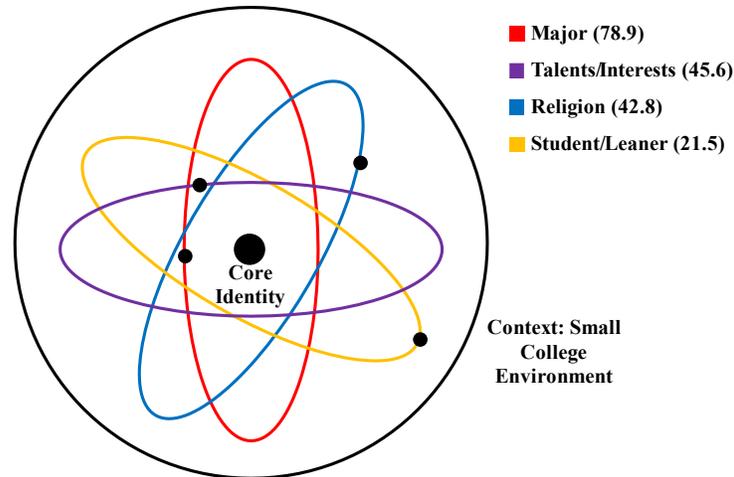


Figure 6: MMDI for gendered responses. Top: Women and nonbinary, Bottom: men. The average ratings (between 1-100, 100 being extremely important) are included in the legend.

Gender is the top identity category mentioned by women and nonbinary participants, but it does not even make the men's top four. This is likely due to the underrepresentation of women and gender-nonconforming individuals in engineering. This is exacerbated in small school environments where a class of engineers may only include a few women. According to the Engineering by the Numbers report [69], 21.9% of bachelor's degrees in engineering were awarded to women. In a small school with an engineering class of 50 students, only 11 would be women. There are no statistics regarding nonbinary or gender nonconforming students in engineering.

## Discussion

The results of this study highlight the significance of the context on the identities expressed by the students. Religious identity was very important to the participants from the balanced/religious college, but engineering/major identity was not the most important identity at the predominately engineering schools. The relationship between identity salience and homogeneity of the environment may have to do with the active encouragement of those identities. At the BR school, religious identity is actively encouraged through mandatory religious services and religion focused activities on campus. Engineering or Major identity is not as actively encouraged outside of curriculum. It is worth noting that Major identity was still rated as one of the top two identities for each school type, showing its significance regardless of if it was actively encouraged.

This study also supports other works [29], [36] regarding gender identity salience in an engineering setting. Regardless of school type, women and nonbinary participants considered their gender to be one of their prevalent identities but only half of the men included it. While the small class sizes offered by small schools are beneficial in many ways, limited representation of women and gender non-conforming students can potentially increase feelings of isolation. Representation among the faculty has been shown to go a long way in supporting these students and increasing their sense of belonging [35]. This is especially important in small school settings

with few engineering professors available. Schools should be hiring with diversity in mind and intentionally trying to increase representation of genders and races among the faculty.

A supportive environment that encourages and accommodates a variety of interests outside of engineering allows for a diversity in identities expressed. Students who attended the PNE school held more identities outside of engineering as important to them compared to the other school types. Where the top identities chosen by participants from the PE and BR schools fell into three identity categories, the top identities for students attending the PNE school were distributed between six categories. The PNE school may be creating an environment that is more supportive of a variety of identities, but it is not perfect. In Riley's case, art was put by the wayside because there was a larger community revolving around sports at the PNE school. They also were hesitant to express their gender and sexual identities because they did not feel comfortable. Dedicated support for LGBTQ+ students on campus could potentially provide a more comfortable space for students like Riley to express and not suppress identities that are important to them. Communities and access to resources can influence how students choose to express their identities. The individualized instruction and academic support that small schools can offer can be beneficial to encouraging a student's engineering identity, but a lack of community supporting other identities can force a student to suppress that identity. Strong engineering identity is important in understanding persistence, but it is also important to remember that there is more to engineers than an engineering identity. Faculty at small schools who wish to effectively educate their students should work to support them as well-rounded people and not as just engineers. By doing so, it supports a variety of perspectives and influences which are vital to effective engineering design. Working with and understanding different perspectives or thought processes teaches the students to be more empathetic and exposes them to alternative solutions.

Faculty at small schools have a unique opportunity in the small class sizes compared to larger colleges and universities. Small class sizes and multiple courses being taught by the same professor often leads to a closer relationship between professors and students. The professor often gets to know each of their students on a more personal level. Through these relationships, faculty at small schools can encourage their students to pursue hobbies, groups, or projects outside of the classroom engineering context that they know the student will enjoy or identify with. This can help encourage diversity of thought and promote the well-roundedness of students for which small schools are known. 83% of the participants in this study believed their school environment had some impact on how they expressed their identities. Faculty at small schools have the opportunity to make that a positive impact through a supportive and encouraging academic (or departmental) culture.

## **Limitations**

This study's results are not representative of every student who decides to attend small colleges and universities. Each individual is unique in their personality, identities, motivations, and experiences. This study is intended to peek into the commonalities in engineering students at these types of schools. Due to the small number of participants, many factors contribute to the variation in responses. The balanced school is also religiously affiliated. Results regarding this

school may be due to either its proportion of engineering representation or its religious values. This school's results are also gendered because only 2 of the participants from this school are women. While literature has shown the significance of racial identity on college students' experiences [37]–[40], a majority of the participants in this study identified as White, and so few conclusions can be drawn regarding racial identity's influence in engineering in small schools from this participant pool. This work presents the start of understanding how engineering identity is unique to students who choose to train in the small school environment.

## **Conclusion**

This study presents the results of an identity activity given to engineering students attending small colleges and universities. These schools offer unique learning environments that have a direct impact on the students. Students were asked to assess the various aspects of their identity, rate their relative importance, and explain how their school may influence those identities. By distributing the results by school type, we see how the homogeneity of a school environment influences which identities are encouraged and how strongly they are expressed. Separating by gender, the results show the significant difference between men, women, and nonbinary engineering students and how they consider their gender identity. The average Model for Multiple Dimensions of Identity based on school type can help understand students' priorities when deciding to attend a small school.

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