Analyzing the Cultural Forms in Engineering Education in Canada

Sophia Stockner

250956560

April 13, 2021

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Prof. Adams

Introduction

Current research points towards a significant lack of representation within the field of STEM (science, technology, engineering, and mathematics). While percentages vary by discipline, engineering has widely been hailed as one of the most underrepresented STEM fields, especially in terms of gender. In 2016, women made up only 23% of engineering university graduates in comparison to 47% of men (Hango, 2013). Women who studied engineering were also found to be less likely to work in the field, demonstrated as only 18% of licensed engineers were women in 2017 (Engineers Canada, 2018; Wall, 2019). These inequalities are problematic, especially given the social and economic prestige associated with the engineering profession. Countless studied have been conducted seeking to address these inequalities, and they point towards a multitude of different factors that play a role in influencing them. From these, a significant number have focused on the socio-cultural aspects within engineering that have played a role in exacerbating some of these inequalities (Dasgupta and Stout, 2014; Lawson, 2020; Dryburgh, 1999; Dutta, 2015; Logel, et al., 2009; Riney & Froeschle., 2012; Sakinah, et al., 2020; Shi, 2018; Wall, 2019). Aspects such as a lack of representation, a pressure to conform to gender roles, differing beliefs in one's abilities, negative stereotypes, and a lack of early exposure to science and engineering, are all factors that have been attributed to exacerbating inequalities within the profession (Blickenstaff, 2005; Dasgupta and Stout, 2014; Riney & Froeschle, 2012; Shi, 2018).

With this, many theorists have also focused on professionalization as a key period in which these inequalities come to be internalized and reproduced (Dryburgh, 1999; Riney & Froeschle, 2012). Professionalization refers to the process in which individuals develop the "skills, identities, norms, and values associated with becoming part of a professional group"

(Levine, 2001). This process occurs as one develops throughout their career, but it can predominately be seen during higher education where students learn the necessary skills and credentials to become a legitimate member of the profession (Levine, 2001). Yet, this process is more complex than merely teaching students the curriculum, as professions require workers who will act and identity themselves as clear members of the group (Levine, 2001; Phillips and Dalgarno, 2017; Stevens and O' Connor, 2005). For these reasons, students must be taught the profession's culture and norms, so that they can come to properly act and shape their identity within it (Levine, 2001; Phillips and Dalgarno, 2017; Stevens and O' Connor, 2005 Thoman, et al., 2017). As professional cultures and norms are shaped throughout history though, many contain subliminal biases and assumptions that can serve to reproduce inequalities. A study conducted by Blickenstaff (2005) found that the different processes of socialization within engineering education were created by men primarily for male professionals. Dryburgh (1999) also emphasized this factor as she found that female engineers had to work much harder and utilize different strategies in order to fit into a highly masculine engineering culture.

Having a thorough understanding of the professional culture of engineering and the ways in which it becomes internalized by its members throughout the period of professionalization is therefore necessary in order to better understand and address the inherent inequalities within it. While some studies have addressed this issue by looking at different professional cultures in a multitude of fields, few have focused specifically on the professional culture of engineering (Becker, 1961; Blickenstaff, 2005; Liberman, 1988; Phalen, 2018; Rosenthal, et al., 2016; Schleef, 2006; Soydan, et al., 2014; Trice, 1993). From the studies that have, the majority are qualitative and emphasize the lived experiences and testimonies of students in engineering education (Cech, 2014; Dryburgh, 1999; Riney and Froeschle, 2011; Stevens and O' Connor,

2005; Stevens, et al., 2007; Villanueva, et al., 2018). While these studies are important and have contributed greatly to the field, I would like to add to this existing literature by providing an in-depth analysis of the culture of engineering itself and the methods in which it becomes decimated and internalized by students. I argue that different cultural forms within engineering education serve to facilitate particular ideologies about engineering and what it means to be an engineer. To understand these, I will be analyzing the different cultural forms of recruitment, academic hazing, and traditions/rituals currently practiced in engineering higher education faculties across Canada, and the ideologies they perpetuate. Hopefully, by having a greater understanding of engineering culture through the cultural forms promoted and socialized in engineering education, researchers can come to better understand the ways in which it contributes to reproducing inequality within the field.

Culture and Cultural Forms

Before analyzing the different cultural forms within engineering education, I would like to begin by providing a detailed definition and explanation of culture and its many features. According to Trice (1993), culture is a set of shared meanings that humans use to understand and bring order to the world. In a broad sense, the purpose of culture is to guide and give meaning to individual's behaviour as they navigate the complex and highly unpredictable nature of life (Sonnenstuhl, 1996; Trice, 1993). In order to do this, culture is made out of two components: ideologies and cultural forms (Trice, 1993). Ideologies refer to the set of beliefs and ideas surrounding how individuals should act and engage within society and the world (Merriam-Webster, n.a.; Trice, 1993). Cultural forms in comparison, are actions, processes, rituals, traditions, and symbols, that individuals take to express and reaffirm their cultural ideologies

(Trice, 1993). Taken together, culture becomes created, reproduced, and strengthened through its ideologies and cultural forms (Trice, 1993).

Similarly, a professional culture is composed of the many beliefs and practices that establish a profession and its standards and norms (Sonnenstuhl, 1996; Tarver, 2021). Like a society's culture, professional cultures also help create meaning and guide workers through the complexity of their job by providing them with a set of assumptions, beliefs, and recommended actions around how to best conduct themselves in their work (Sonnenstuhl, 1996). As this process enforces certain notions around how workers should and shouldn't comport themselves, it also serves to encourage homogenization, helping to create a sense of solidarity among workers (Sonnenstuhl, 1996; Trice, 1993). A highly homogenous and solidary workforce is important in a profession, as professions require workers that will behave and identify as clear and legitimate members of the group (Sonnenstuhl, 1996). Besides this, a profession's culture also serves to establish a dualism between "insiders" who are part of the profession and "outsiders" who are not (Gieryn, 1983; Sonnenstuhl, 1996; Trice, 1993). This serves to regulate a profession's activities and the way in which they are performed, allowing professionals to establish clear boundaries that separate the profession from others (Gieryn, 1983; Sonnenstuhl, 1996). In turn, this gives the profession and its members more legitimacy in society and also serves to reinforce the profession's dualistic ideologies and cultural forms (Gieryn, 1983; Sonnenstuhl, 1996).

Recruitment

The first cultural form present in engineering education begins even before students have joined the program: recruitment. It is a commonly known fact that recruitment into engineering

is much harder than recruitment into other disciplines. Engineering programs require many pre-requisite courses in science and mathematics, even more so than other STEM fields. For example, at McGill university, admissions to the engineering undergraduate program require an additional two specified courses in comparison to other majors in science (McGill, n.a.). Prospective science students also have more autonomy on the types of courses they can choose to take before applying, as the engineering program has a clearly defined list of potential pre-requisites with highly limited options (McGill, n.a.). Many engineering programs also require pre-requisite courses to be taken at the advanced placement (AP) level and options to specialize later in one's degree are also more readily available in other majors (McGill, n.a.; University of Waterloo, n.a ; Western Engineering, n.a.[a]). These differences in the recruitment process of engineering compared to other faculties can be overtly seen in universities across Canada (The University of British Columbia, n.a.; University of Toronto: Engineering, n.a.;.; Western Engineering, n.a.[a]).

The rigorous recruitment process observed in engineering makes sense given the complexity of the field and its high focus on mathematics and science. Yet, the extent of this difficulty is surprising given the increased flexibility observed in other similar majors. As mentioned previously, other STEM degrees like computer and medical sciences tend to offer a greater number of options in the types of pre-requisites courses students can take to apply to the program (McGill, n.a.; University of Waterloo, n.a.; Western Engineering, n.a.[a];). Besides this, other professions like medicine and law also offer options for those without the necessary pre-requisites to transition into the field through aspects like upper year specializations and graduate programs. In comparison, the pre-requisites required in engineering are tightly defined and options to transition into the field after an undergraduate degree are practically non-existent

(Ohland, et al., 2008). This can be demonstrated as a study conducted by Ohland, et al. (2008) found that engineering was one of the lowest joined majors after first year. These aspects serve to demonstrate a fundamental purpose of the recruitment process as a cultural form. Like professional culture, the process of a difficult and rigorous recruitment serves to establish clear boundaries to distinguish the profession very early on (Sonnenstuhl, 1996). As previously mentioned, professions regularly engage in boundary work to make a distinction around who is and isn't a part of the profession, serving to regulate their work and establish legitimacy among their members (Bucher, et al., 2016; Gieryn, 1983; Saukko, 2011; Sonnenstuhl, 1996; Trice, 1993;). Through the difficult and highly inflexible process of recruitment, a clear boundary is set between those who completed the necessary pre-requisite courses and those who did not. With this, the many pre-requisites required for engineering undergraduate admission also require a lot of previous planning, limiting a substantial number of prospective students from entering the field. Paired with the difficulty of transitioning into engineering later, a strong boundary is upheld within the faculty, allowing only a select group of individuals the legitimacy to call themselves engineering students (Ohland, et al., 2008). This, in turn, serves to increase the high social prestige of the field, as well as establish solidarity and a sense of uniqueness among its members.

Academic "Hazing"

Unfortunately for many engineering students, the difficulty of the program does not end with recruiting. As a faculty, engineering is ubiquitously known as one of the most challenging and academically demanding, especially in a student's first years (Stevens, et al., 2007). Many studies have found that engineering students consistently report it as one of the hardest majors

and engineering programs commonly have a heavier course load with seven rather than the usual five courses found in most other academic departments (Dryburgh, 1999; Ohland, et al., 2008; Stevens, et al., 2007). The inflexibility found in recruitment also translates into engineering courses, as most classes require many specific pre-requisite courses, and the prevalence of a heavier course load means students do not have many opportunities to take electives (Cech, 2014; Stevens, et al., 2007). In some engineering programs like at the University of Western Ontario, first-year student timetables and courses are even chosen by the faculty in advance (Western Engineering, n.a [b]).

Although the inherent difficulty of engineering is expected given the complexity of the profession itself, many have outlined that the extent of the challenge and the increased workload of engineering degrees is largely manufactured and not as necessary as it seems (Stevens, et al., 2007). A study by Stevens et al. (2007) found that the challenge of engineering classes had more to do with the experience of difficulty rather than the content itself, as only a portion of the content taught in engineering education was reported to be utilized in the field. Previous engineering graduates also echo this point as many have stated that a large percentage of first-year classes seem unnecessary and do not touch on the practical components of the field (Drew, 2011; Villanueva, et al., 2018). Many have also questioned the necessity of the extra classes required for engineering students as well as the lack of autonomy in class selection (Drew, 2011; Stevens, et al., 2007). This is especially true given that other degrees, including many in STEM, allow more room for electives and give students alternative options like the ability to take fewer classes and prolong their degree. For these reasons, it is clear that the ubiquity of harder and heavier classes in engineering education is more than just an outcome of the inherent difficulty of the field. Instead, a harder and heavier course load is another cultural form that plays a role in

creating, reproducing, and decimating certain ideologies within the profession. From these, the most common are ideologies surrounding boundary setting and the promotion of solidarity and bonding.

Paralleling recruitment, the cultural form of harder classes and a heavier course load serves to establish strict boundaries within the profession by restricting access even further to those who can successfully pass the rigorous academic load. This can be demonstrated in a study conducted by Dryburgh (1999) where many engineering students mentioned the first few years in engineering as a rite of passage that serves to restrict entry into the field. As one engineering student in the study noted, "my whole attitude was: I made it through first year, I can make it through anything at this point" (Dryburgh, 1999, p. 671). Yet, the use of heavier classes also adds further to this type of boundary setting by establishing a clear hierarchy within the field. Coined the meritocracy of difficulty by Stevens, et al. (2007), this hierarchy is based on the assumption that because something is harder to do, it is also more superior– and this is a common assumption within engineering. Following the meritocracy of difficulty, engineering is positioned as an inherently superior faculty in comparison to others, purely due to the difficulty of its work (Stevens, et al., 2007). This ideology also serves to create a hierarchy within engineering as certain specializations are viewed as inherently inferior to "harder" ones (Stevens, et al., 2007). Besides this, the meritocracy of difficulty also serves to establish the idea that only those who sacrifice a lot and work extraordinarily hard can be engineering students, further serving to establish boundaries (Stevens, et al., 2007).

Yet, restricting boundaries and positioning engineering as a superior discipline are not the only results of a difficult course load. Paralleling the process of hazing commonly seen in fraternities and other social groups, the harder course load observed in engineering also serves to

establish a clear sense of solidarity and bonding among its members. In the process of hazing, new or perspective members of a group are intentionally abused, harassed or mistreated in some way (Cimino, 2011). As hazing is illogical and unpleasant, it often provokes cognitive dissonance in individuals, which is a feeling of discomfort that arises when one's actions contradict one's beliefs (Aronson and Mills, 1959; Cimino, 2011). This feeling of discomfort only subsides when individuals make sense of their actions and re-align them with their beliefs (Aronson and Mills, 1959; Cimino, 2011). For this reason, individuals who undergo hazing often end up gaining positive feelings about the hazing group and an increased solidarity towards it, in an effort to makes sense and rationalize their unpleasant and illogical experiences (Aronson and Mills, 1959; Cimino, 2011). Besides this, hazing is also found to increase bonding among group members, as painful shared experiences have been shown to bring individuals together, acting as a form of "social glue" and serving to increasing cooperation (Brock, et al., 2014; Whitehouse, 2012). In a similar sense, engineering's harder and heavier course load acts as a form of "academic hazing", as students gain solidarity and positive feelings about the degree to rationalize its increased workload and the sacrifices it brings (Dryburgh, 1999; Stevens, et al., 2007). Aside from this, engineering's academic hazing also works to promote bonding, as students relate over the shared experience of a heavier and harder course load (Dryburgh, 1999). It is likely also for this reason that ideologies like the meritocracy of difficulty arise. By promoting an ideology like the meritocracy of difficulty that positions harder disciplines as better, students are able to rationalize and even feel positive emotions like pride towards the increased time and effort spent in a heavier and harder course load.

Traditions and Rituals

Besides academics, there are also many cultural forms in the shape of traditions and rituals that also serve to promote a variety of ideologies and professional beliefs. From these, some of the most ubiquitous and well-known are the traditions and rituals of purpling, engineering jackets, pranking, and the "Ritual of the Calling of the Engineer".

Purpling

One of the most ubiquitous and obscure engineering traditions is the act of purpling. According to the University of Waterloo, "purpling is the act of dying your skin purple out of respect for the engineering profession and dedication to your school" (Waterloo Engineering Society, n.a.). It is a common practice throughout engineering faculties across Canada, especially during events like Orientation or Frosh weeks where incoming students are often completely submerged in large vats of purple dye (Ryerson Engineering, n.a; Waterloo Engineering Society, n.a..). As purpling is a very old tradition, no one knows the exact origin of the practice but there are many stories around it (Ryerson, Engineering, n.a.). From these, the most commonly cited by the majority of schools revolves around the engineers aboard the Titanic. According to the legend, as the Titanic began to sink, the engineers aboard the ship remained in the furnace room until their deaths, producing smoke so that it could signal other ships (Ryerson Engineering, n.a.; Waterloo Engineering Society, n.a.). As the engineers on the Titanic wore purple coveralls, engineering students dye themselves purple during events to commemorate their bravery and sacrifice (Waterloo Engineering Society, n.a.).

Paralleling the goals of academic hazing, the cultural form of purpling within engineering education also serves to establish solidarity and bonding. Although far more pleasant than a heavy course load, the act of purpling is still illogical and involves some degree of social

embarrassment, as covering oneself in purple dye is bound to evoke strange looks from peers. Due to this, the practice also serves to increase solidarity, as students develop positive feelings around purpling in order to rationalize it, and bond due to the shared experience of engaging in a strange act. Visually, the practice of purpling also enforces notions of homogenization, serving to reinforce solidarity among group members and making it easier for students to identify and showcase themselves as clear members of the group (Sonnenstuhl, 1996; Trice, 1993). This can be overtly demonstrated in a statement made by a second-year engineering student at Laurentian University: "What's cool [about purpling] is when I see someone purple and we give them the look and we're like, yeah engineers," (Wilmont, 2014).

Engineering Jackets

Surprisingly, purpling is not the only clothing-related tradition involved in the faculties of engineering, as the engineering jacket is one of the most well-known. The engineering jacket is usually a bomber-style leather jacket that students can purchase after their first year, once they have been formally admitted into their engineering major (ASUS, n.a.; Dryburgh, 1999.). Jackets often contain writing highlighting a student's major and graduation class, as well as patches and other accessories, depending on their school and program (ASUS, n.a.; Dryburgh, 1999; Ryerson Engineering, n.a; Waterloo Engineering Society, n.a.). As students are not allowed to purchase a jacket until they complete their initial year, the engineering jacket is highly symbolic, and many schools also contain rituals and events surrounding its acquisition (ASUS, n.a.; Dryburgh, 1999; Soltys, 2014). For example, at Ryerson University, engineering students have a specified "Jacket Night" where their engineering jackets are officially initiated (Ryerson Engineering, n.a.). At the University of Queens – whose engineering faculty is famous for its complex and obscure

engineering jacket traditions – a common rituals is that students are not allowed to pick up their jackets upon purchase, and instead must kick them back to their home (ASUS, n.a.; Soltys, 2014).

According to Dryburgh (1999, p. 672), the engineering jacket "is the first sign of solidarity with the profession", as it acts as an overt symbol of a student's completion of their first-year rite of passage. By wearing the jacket, students convey to others and to themselves that they have successfully surpassed the difficulty of academic hazing and are now legitimate members of the engineering faculty (Dryburgh, 1999). This, in turn, helps students form their official identity as an engineer and showcase it to others for the first time, increasing solidarity and serving as an important professional milestone, especially given the importance in professions to identify as a clear member of the group (Dryburgh, 1999; Sonnenstuhl, 1996).

Pranking

Although less formal, another tradition that is common and has a long history in engineering faculties across Canada is pranking. Engineering students are known for their often elaborate and large-scale pranks that showcase the many mechanical and physical feats possible in engineering (Millar, 2007; Reuter, 2016). In 2011, for example, engineering students from the University of British Columbia made headlines by dangling a Volkswagen beetle from San Francisco's Golden Gate Bridge (Millar, 2007). Castle, an engineering professor at the University of Western Ontario, also helps explain the ubiquity of this phenomena, as he dedicated an entire portion of his book on engineering to the many pranks conducted by the engineering faculty (Reuter, 2016). In Waterloo, pranks are organized by a secret committee referred to as the "Non-Existent Action Committee", which is run by engineering students and

which secretly pull pranks on other Waterloo faculties across campus (Waterloo Engineering Society, n.a.). Other engineering faculties across Canada like the University of Toronto and Queens are also known for having very old and long-established traditions of pranking (Millar, 2007; Reuter, 2016).

Yet, pranking does more than showcase the many feats made possible by the field of engineering. Like other traditions, pranking is also a cultural form that serves to establish particular ideologies surrounding social boundaries and the creation of solidarity. Firstly, the secretive and targeted nature of pranking makes a natural insider/outsider divide, as clear boundaries are established between the engineers doing the pranking and those receiving the prank. As pranking is also a form of deviant behaviour, it carries certain risks, and like academic hazing and purpling, the shared experience of pranking also serves to promote solidarity and trust. This is especially true given the high degree of secrecy involved in pranking, overtly demonstrated by the "Non-Existent Action Committee" at Waterloo (Waterloo Engineering, n.a.). Like unpleasant experiences, the experience of a shared situation that involves secrecy and risk has also been shown to promote social bonding and aspects such as trust and cooperation, in a similar way as hazing (Brown, 2019; Cruwys, et al., 2021).

Iron Ring and The Ritual of the Calling of an Engineer

The final and often labelled as the most important tradition in engineering education is the "Ritual of the Calling of an Engineer". "The Ritual of the Calling of an Engineer" is a private ceremony that engineering students are allowed to attend in their graduating year (Dryburgh, 1999; Camp One, Greater Toronto Area, n.a.). The ceremony was first created by H. E. T. Haultain, an engineering professor, and famous author Rudyard Kipling in an effort to bind

members of the profession closer together and ensure that newcomers comply to the values of the profession (Camp One, Greater Toronto Area, n.a; Pfotnüller, 2019; The Wardens of Camp One, 2017). At the ceremony, students take an oath to practice engineering while upholding a set of ethical and professional standards (Camp One, Greater Toronto Area, n.a; Dryburgh, 1999; The Wardens of Camp One, 2017). According to the University of Toronto, these standards can broadly be defined as a standard to "eliminate faulty workmanship, strive generously towards perfection, be honourable and fair, admit and deal with your mistakes, and respect and support your colleagues" (Camp One, Greater Toronto Area, n.a., p. 20). After the oath, students are then given an iron ring to wear on the smallest finger of their working hand that symbolizes and serves as a continual reminder of the oath that they took and the standards they promised to uphold (Camp One, Greater Toronto Area, n.a; Dryburgh, 1999; Pfotnüller, 2019; The Wardens of Camp One, 2017).

Like engineering jackets, the "Ritual of the Calling of an Engineer" is deeply symbolic and acts as a way for students to officially establish their legitimacy and identity as an engineer (Dryburgh, 1999; Camp One, Greater Toronto Area, n.a; The Wardens of Camp One, 2017; Pfotnüller, 2019). By taking the oath, students formally agree to follow the profession's ideologies and to uphold its norms, acting as the last stage in the process of professionalization (Camp One, Greater Toronto Area, n.a; Dryburgh, 1999; Levine, 2001; The Wardens of Camp One, 2017). In doing this, the oath also acts to binds students to each other and establish solidarity and homogeneity, albeit in a very different sense than other cultural forms like academic hazing or purpling (Dryburgh, 1999). Rather than establish solidarity through hardship or ridiculous tasks, the ring serves as a more permanent reminder of the profession and the shared oath one takes with other engineers (Dryburgh, 1999; Pfotnüller, 2019). Like pranking,

the solidarity that arises from the ritual is also exacerbated by the secretive nature of the ceremony, as attendance is restricted to fourth year engineering students and "Wardens" who are chosen experts in the profession (Camp One, Greater Toronto Area, n.a; The Wardens of Camp One, 2017). Apart from this, previous graduates are also commonly encouraged not to disclose any details of the ceremony to others (Camp One, Greater Toronto Area, n.a; Pfotnüller, 2019).

Conclusion

Current research has pointed towards a large problem regarding representation in the field of engineering. With this, many studies have also outlined the period of professionalization as a significant period in which these inequalities become reproduced and learnt through the culture within the profession. I argue that various cultural forms practiced during the period of professionalization in engineering education serve to decimate particular ideologies and professional beliefs. In order to understand these, I analyzed the cultural forms of recruitment, academic hazing, and traditions/rituals that are commonly practiced in engineering faculties across Canada. From my analysis, it was clear that these practices do indeed serve as cultural forms and act to decimate particular ideologies and values about the field, particularly around the enforcement of strong boundaries, a meritocracy of difficulty, and solidarity and homogenization. These insights help provide a deeper understanding of the ideologies and beliefs that are perpetuated in engineering education. By having a better understanding of these beliefs and the ways in which they become decimated, researchers can hopefully gain a fuller understanding of engineering culture and its possible effects.

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