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'It Gives Me a Bit of Anxiety': Civil and Architectural Engineering Students' Emotions Related to Their Future Responsibility as Engineers

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‘It gives me a bit of anxiety’: Civil and Architectural Engineering Students’ Emotions Related to Their Future Responsibility as Engineers

Emotion is an integral part of teaching and learning, intertwined with students’ responses to topics, reactions to experiences in the classroom, and interactions with peers and faculty members. However, emotion is under-researched in the context of engineering education. This research paper explores civil and architectural engineering students’ emotion related to their ethical and societal responsibility. This research is part of a larger study in Belgium and England that examines students’ conceptualization of their societal responsibility and the factors inside and outside the classroom that shape it. Preliminary analysis of the interview data indicated the role of emotion in students’ understanding of their future responsibility as an engineer. The present study probes this emergent finding with a social constructionist approach, which describes the theoretical perspective that emotions are a sociocultural experience and are situated rather than a purely individual and internal phenomenon. The present paper examines eight interviews conducted with students at one university in Belgium and the emotions that students express related to their future responsibility as an engineer. Students voiced fear, stress, anxiety, and pride when considering the responsibility of engineers. The analysis also explores the sociocultural factors that may contribute to these emotional responses, such as the disconnection between engineering education and practice, narrow idea of responsibility, and perceived importance of engineers. The implications of this research are a contribution to the growing conversation around emotion in engineering education, including how emotions can be socially constructed and affect students’ perspectives on their future responsibility as engineers.

Introduction and Background

Research and education related to engineering ethics have grown in recent decades, in part due to international efforts such as the Washington Accord [1] and the globalization of the engineering workforce, which highlight the need for ethics to be embedded in engineering practice. Undergraduate education plays a key role in socializing students into the engineering profession and developing their requisite competencies, including those related to ethical and professional responsibilities. Research on engineering ethics education has focused on the integration of ethics in the curriculum such as the topics, pedagogies, and settings [2][3][4], and these reviews synthesize the body of work on descriptions and outcomes of individual classroom interventions. There is recent momentum towards a broader conceptualization of ethics from individual duties to clients and employers (microethics) to the responsibilities of engineers to society, the environment, and nonhuman life (macroethics) [5][6][7]. This study centers the macroethical conceptualization of ethics and explores the interplay between students’ perception of responsibility and emotion.

Emotion in Engineering Education

Emotion is a ubiquitous part of education and has grown as a research area in recent decades [8]. This work identifies achievement emotions (related to students’ feelings of success and failure), social emotions (the relational aspect of learning), topic emotions (reactions to content), and epistemic emotions (those experienced from learning new material) [9]. However, the study of emotions in engineering has lagged in part due to the perception of engineering as a rational and

value-neutral profession [10] with a duality between thought and emotion [11]. To synthesize the disparate literature on this topic, an international group of scholars has undertaken a systematic review of emotion in engineering education [12][13]. The review includes 184 publications and indicates research on emotion in engineering education has increased exponentially since 2001 [13]. This work is dominated by quantitative approaches and psychological perspectives, such as student self-reports of emotion. Of the 184 publications included in their scoping review, only 4% related to moral and ethical emotions [13]. Work at the intersection between emotion and ethics includes empathetic perspective-taking [14]; empathy and care [15]; and risk and design [10]. Given the role of emotion in ethical decision-making [10][16] and risk management [17] and the interplay between ethics and empathy [15][14], it is important to understand how emotional engagement can support ethics education and how emotions affect students' perceptions of their ethical responsibilities.

Research Questions

This study addresses the following research questions:

1. What emotions do students express related to their future responsibility as civil and architectural engineers?
2. How, if all, does the engineering culture contribute to students' experience and expression of emotion related to their responsibility?

Theoretical Perspective

The range of settings and disciplines in which emotions are studied has led to a varied and fragmented understanding of emotion [18]. Emotion has been researched in sociology, psychology, and philosophy leading to different theoretical stances [8]. The present study draws on emotion as a sociocultural experience, which is rooted in anthropology and sociology [8]. Social constructionist approaches describe the understanding of emotion as a sociocultural experience. This stance is in contrast to psychological and physiological perspectives of emotion as an individual and internal experience, also termed positivist [19] and naturalistic [20]. Social constructionism explores emotion through language and behavior rather than biological markers [21]. Central to social constructionist approaches is the notion that the experience and expression of emotion are dependent on cultural norms and are therefore not universal. In the past two decades, there has been growing research in education using social constructionism. However, the aforementioned review of literature on emotions in engineering education indicates a lack of studies with a cultural and sociological focus, and the authors call for broader engagement with socio-cultural perspectives in engineering education [13].

Methods

Project Context

The present study is part of a larger project that is exploring macroethical development in civil and architectural engineering among Bachelor's students in Belgium and England [22]. The project employs a constructivist grounded theory approach [23] to develop an emergent theoretical model of how civil and architectural students develop their understanding of societal

responsibility inside and outside the classroom while drawing on experiences before and during university. The project includes in-person, semi-structured interviews with students at one university in each of the two countries. Data collection and analysis are ongoing, and a total of twelve (eight in Belgium and four in England) interviews have been conducted.

Participants

The present study focuses on interviews with eight students at one university in Belgium. Since this study draws on a social constructionist perspective, culture is important in understanding the expression and experience of emotion. The study is scoped to participants in one country to examine the possible effects of culture, since the students in another country could experience a different social reality [21]. Information on the civil and architectural engineering students in Belgium is provided in Table 1. Seven of the participants were born in Belgium and one was born in the Netherlands. Gender was not a criterion in participant selection, but women are overrepresented in the sample compared to the 25.8% of women in STEM Bachelor's programs in Belgium [24].

Table 1: Participants

Pseudonym	**Year in Program**	**Gender**
Anna	2	Woman
Brigitta	2	Woman
Hann	2	Woman
Henriette	2	Woman
Joris	2	Man
Naomi	3	Woman
William	1	Man
Wallorroo	2	Woman

Data Collection

In aligning the theoretical perspective with the methodology, a quality consideration for interpretive research [25], a qualitative approach was appropriate for social constructionist work to understand the process and meaning of emotions [8]. This study employed semi-structured interviews and took a cross-sectional approach to include participants at every level of their Bachelor's studies in civil and architectural engineering. As a note, the Bachelor's program in Belgium is three years so students in years one through three are included. For participant recruitment, the secretariat of the engineering faculty was contacted to advertise the study on the Canvas page for the Bachelor's students. Additionally, individual professors in the program were emailed with information on the project and a request to share it with their students. Students were invited to send an email to the researcher to express their interest in participating or learn more about the study. Through this process, eight interviews were conducted in April and May 2022. The interviews were semi-structured to provide flexibility in eliciting the participants' authentic perspectives and co-constructing meaning through their experiences [23]. Prior to the interview, the participants were given consent forms, which were discussed at the start, and verbal or written consent was collected. The interviews were audio recorded. At the beginning of

the interview, students were asked to self-identify their year in the program, place of birth, gender identity, and race/ethnicity. They were welcome to skip any demographic questions they did not feel comfortable answering. The interviews questions explored students' perceptions of good engineering, the impact of engineering, and the responsibility of engineers. The interview employed critical incident techniques [26] to prompt students to give specific examples and moments. Expressions and experiences related to emotion emerged in response to the question "What feelings come to mind when you think about your future responsibility as an engineer?" and organically throughout the conversations.

At the end of the interview, the participants were asked to select a pseudonym. If they chose not to, they were assigned one with a random name generator using the gender and race/ethnicity information they provided. The participants were given a renumeration of 10 euros. The research was approved by the Ethics Committee for Human Sciences at the university where data collection took place.

Data Analysis

Transcripts were developed from the audio recordings using an online service. The author verified the accuracy of the transcripts and removed identifying information. Data analysis was conducted in Dedoose, a web-based qualitative and mixed-methods analysis platform. The first step in the analysis was reviewing the complete manuscripts to immerse in the data. Thematic analysis [27] was employed to identify patterns in the data related to students' emotional responses to responsibility and the factors within the engineering culture that may contribute to them. In the first iteration, codes were identified related to each research question. In the second iteration, themes were developed from the codes to inform the findings.

Positionality

The positionality statement is written from the perspective of the author, who conducted the interviews and analysis. Data collection and analysis were informed by my position as both an insider and outsider. With undergraduate and postgraduate degrees from a department of civil, environmental, and architectural engineering, I am familiar with both the coursework and language of the discipline. I mentioned my background in the interviews to support resonance with the students. Although I currently live in Belgium, I am not Belgian nor was I educated in the Belgian system. Specifics of the curriculum and the overall university experience were different from my own. When I did not understand a term used in the interview, I would ask clarifying questions to establish the context from which the students were speaking. I approached these conversations with humility as I sought to learn with the participants as they are experts in their own experience.

Limitations

The findings are reflective of the students who chose to participate in the study and thus self-selected to engage in an interview on ethics and responsibility that was conducted in English.

The university at which the interviews took place is Dutch and English speaking, but most Bachelor's programs are taught in Dutch, which was the native language of all of the participants.

There is ongoing conversation around the inclusion of demographic questions in interviews [28], including where they should be placed and what effect they might have on the participants and their responses. In this study, demographic questions were asked at the beginning, but future interviews might include them at the end to avoid the potential of stereotype threat related to students' self-identification of gender and race/ethnicity.

The present study is part of a larger project examining macroethical development, and thus, emotion was not the central focus of the interviews. The semi-structured questions were not designed to explore emotions nor the culture around them, instead, these findings emerged organically in the conversation or in response to the one question mentioned in Data Collection. The present study is a preliminary exploration of the role of emotion in engineering students' conceptions of responsibility to contribute to the growing discourse around emotion in engineering education. Situated within a constructivist grounded theory project, the current analysis also informs future data collection, which can take a more explicit approach to eliciting an understanding of emotion.

Although this work takes a social constructionist approach, it recognizes emotions are not entirely culturally constructed. The present study did not examine biological and physiological components of emotions, which could be explored through multi-modal approaches to capture the complexity of emotion [29]. Emotion in engineering education has been conceptualized as both an individual and sociocultural phenomenon (for example, [30]), which could be explored in the context of ethical responsibility in future work.

Findings

The following sections detail the findings by research question.

RQ 1: What emotions do students express related to their future responsibility as civil and architectural engineers?

Students' emotional responses to their future responsibility as engineers centered on fear, stress, anxiety, and pride, which are detailed in the following sections and supported through participant quotes.

Fear

The most commonly expressed emotion in relation to their future responsibility as engineers was fear. Three of the students described feeling scared or fearful when they considered their responsibility as practicing engineers. When asked how she felt about her future responsibility, Henriette responded,

> It's pretty scary… It's like scary to think if anything, a small mistake maybe, and your life will be over if there are people inside and they [pause]. Yeah, It's scary.

Brigitta similar expressed fear based on the responsibility of architectural engineers to human lives.

> It scares me a little because I know if I do it, it won't be just me. I will be with a team, and it's comforting, but it's still a lot of pressure because you really have to do good. It's not like you can... It's also not something that you can say, 'Oh, I'll try again.' No, if the bridge collapsed, you can't really just say, 'Oh, let's try again.'

For both students, fear was associated with the high stakes of engineering practice and the small margin for error. However, this fear was tempered to some degree for Joris knowing that responsibility would be shared since engineers work in teams. Joris explained,

> It also kind of scares me, not really scares me because I know that for the career path I want to pursue I know that I want to design in groups, so it's not going to be my own personal responsibility. I'll still share that responsibility with some people, I assume.

Joris perceived that teamwork and distributed responsibility lessened the fear he felt. However, him using the language "I assume" implies that he is not entirely sure of the reality of working as an engineer.

Stress

Two of the participants described feeling stressed about their future responsibility as engineers. Naomi framed her feelings toward her future responsibility as "kind of stressing" while Anna acknowledged that as a working engineer,

> Maybe I'm going to be under a lot of stress because I'm not that good at coping with stress, but I'm learning. I think, by doing stuff that's pushed me out of my comfort zone, maybe that will train me to control my stress more. But I think it's going to be stressful to have that responsibility.

Anna described throughout her life, and especially during university, she has worked to manage her stress. She expected that will support her in managing the stress that comes with the responsibility of being an engineer.

Anxiety

One student described anxiety as a feeling that comes to mind when thinking about her future responsibility. Naomi stated,

> It gives me a bit of anxiety, actually, because it's not possible. If you're graduated, all the things you have learned during those years, you have to translate them in the real world and actually work with all the information you got. But it's like two different kinds of

> worlds. Now you're a student, but then you are like ... It's our profession. We have to do it every day, actually.

Naomi explained that the anxiety stemmed from transitioning from being a student to a professional. The perceived disconnection between them as "two different kinds of world" contributed to this concern.

Pride

One student described a positive emotion, pride, when considering the responsibility of engineers. Joris stated,

> Well, first of all it makes me sort of proud that I have that responsibility in the first place, because in order to graduate from this course and then be in a position that I can have that responsibility it takes so lot of work. But I actually don't mind responsibility at all, I think it's good for people to search for responsibility because it gives a real meaning to what you're doing.

For Joris, pride was associated with earning the responsibility of being an engineer by completing the Bachelor's course and finding meaning in the work he would be doing.

RQ 2: How, if all, does the engineering culture contribute to students' experience and expression of emotion related to their responsibility?

Three themes were identified that related aspects of the engineering culture to students' emotions connected to their future responsibility as engineers.

Narrow idea of responsibility

Five of the eight participants spoke about the impact of engineering and the responsibility of engineers in terms of making sure the bridge or building does not fall down. When asked to describe examples of responsibility or experiences in which they learned about it, the most common response was learning about bridge and building collapses. Henriette described this responsibility,

> I think that's a really big responsibility because when you, for example, design material, you have to really know it's good enough that it will not break. When your material is used in buildings, people's life will depend on it. If it collapses with a lot of people in it, there comes a lot of responsibility with that.

Anna similarly situated her understanding of good engineering,

> I think, an engineer has a lot of responsibilities. Take the example of a bridge. If there's something wrong in a little calculation, the bridge could fall, and the engineers behind it are at fault. So that's what I think of an engineer.

Joris noted, “architectural engineers have a certain responsibility, not only if your building collapses, but also if it just works and functions fine.” Brigitta expressed a similar understanding of responsibility and explained that it stemmed from how engineering was framed in the classroom.

> I think it's a degree that comes with great responsibility. I feel like sometimes now, if we get classes that are talking about the mechanics about bridges and sometimes I go, ‘One day I might have to do that’ and it's my responsibility because you don't want it to fall down when there's people on it. So when I think about I'm like, ‘Whoa, that's a lot of responsibility.’… They [professors] often show examples where it went wrong. I think it's also to make clear like, ‘Don't do this.’

Students learned through disaster examples of the impacts of engineering and the responsibility of engineers to avoid such wrongdoing. The comments threaded throughout the interviews indicated a narrow idea of responsibility. Although human safety is a paramount responsibility of the engineering profession, it is one of many ethical issues embedded in engineering practice. Students were prompted to provide further examples of impact and responsibility in engineering, and although a few made briefs mentions of sustainability, the incidents they drew on from their courses centered on avoiding bridge and building collapses.

<u>Disconnection between learning and practicing engineering</u>

A second theme that emerged related to the cultural construction of students’ emotions associated with responsibility was the perceived disconnection between learning and practicing engineering. As an example, Anna described course projects as “fiction.”

> It's also always like our projects for designing buildings, it's fiction. We're never going to make it real life, so we know that it could never be executed because we don't have all the knowledge yet to execute it perfectly. So we are still in a learning phase, so the experience comes afterwards, I think.

Anna went on to explain that part of the disconnection between class projects and the reality of engineering work is that cost is not considered in buildings designed for courses. Although “everything is money”, Anna said her classes did not teach the economics of engineering. Hann expressed a similar frustration in describing her second-year design project.

> I'm really like focusing on making it financially possible, which is something they [professors] don't look at all. And I do think that's important. They're always like, ‘Oh, it's an academic exercise. You can go out of the box, you can do crazy things.’ But then in three years, I'm going to have to know how to make something that's actually doable. So yeah. I do feel like they think like it's a bit fiction to them or something, which is obviously not quite correct to say because they are architects. They know what they do obviously, but I think they just don't want to get bored.

Hann made the distinction between what her professors were prioritizing in design projects and what factors govern engineering in practice. She similarly used the term “friction” to describe the projects and instead wished the curriculum prepared students to make feasible designs.

Importance of engineers

A third theme is the societal importance of engineering and how this contributes to the weight of responsibility on engineering students. Participants echoed the societal impact of civil and architectural engineers with everyday life serving as a reminder through the buildings in which we live, work, and study. Joris described this impact as being able to “engineer the way people walk through your building and therefore kind of manipulate the way people walk through your building.” This power in affecting the way people function through their daily life plays into the perceived importance of engineers and is reinforced in the culture of engineering education. When asked to describe the impact of engineering, Anna responded

> I think you just have to look around you. I mean, the world is made by engineers. But you need everyone. In the world, it's not that engineers are the gods of universe, but I think, if you look around, everything has some type of engineering behind it.

This comment communicated the visible contribution and therefore importance of engineers, but Anna acknowledged that everyone is needed in a way that subverts the dominant cultural idea of engineers being “the gods of universe.” Hann situated the weight of this responsibility with the need to be sufficiently prepared for it.

> Well I think, yeah, the responsibility is huge obviously. That's also kind of why I have these thoughts about the professors not being realistic enough, because obviously they realize the responsibility, they do. But I don't think they realize that we do not have the knowledge to get that responsibility.

Discussion

This research explores emotional responses to civil and architectural students’ future responsibility as engineers and the role that engineering culture might play in how those emotions are experienced and expressed. The findings highlight feelings of fear, stress, anxiety, and pride while the disconnection between learning and doing engineering, narrow focus on making sure bridges and buildings do not fall, and societal importance of engineers contribute to how students construct their understanding of responsibility. Taken together, these aspects of the engineering culture and curriculum left students with a narrow but high stakes understanding of the responsibility of engineers and a feeling of limited preparation for it. The combination of seeing engineering education as “fiction” while hearing the human cost of engineering mistakes through examples in their classes played into the strong emotional response students had when prompted to consider their feelings about being a working engineer in the next few years. This synthesis at the intersection between the two research questions relates to research on shame in engineering, which found that tension between the global identity of engineers and students striving to the worthiness of being an engineer in both proving themselves and contributing value to the world contributed to their emotional response of shame [30].

It is important to note that students can hold different meanings of the words they use to describe their feelings. Three students used the word "scared" and two described being "stressed"; however, it is unclear if they ascribe the same understanding to those feelings. It is also not clear if their understandings align with definitions in psychology (for example, stress being the physiological or psychological response to stressors that affects the body's systems and person's behavior [31]) or in sociology (for example, stress being a demand that people confront and that stems from social structures [32]). Data collection was not designed to probe these definitions, but future work could further unpack their meaning for the participants.

The prominence of negative emotions (fear, anxiety, and stress) in the present study raises questions about how the environment and curriculum of engineering might be impacting students' feelings toward their future responsibility, which can have effects inside and outside the classroom. One implication of emotion is understanding its impact on students' motivation and achievement. As one of the pioneers of research on academic emotions, Perkun [33] found positive emotions predicted higher achievement while negative emotions predicted lower achievement. Pride, for example, was correlated with increased effort, motivation, and interest [33]. However, the conversation around emotion and responsibility is more nuanced. Research has found that negative emotions can be related to moral responsibility and spur action in the face of injustice, for example anger being more motivating than sympathy [34]. Despite the connotation, negative emotions can lead to positive responses and warrant further consideration in the context of ethics and responsibilities. One caveat in interpreting the findings is the potential influence of the word "responsibility" in eliciting an emotional reaction. Although the data leaned toward negative emotions, responsibility can also be associated with positive emotions such as hope and compassion. Since data collection and analysis are iterative in the larger grounded theory project, future work could explore how re-framing the wording of the questions might elicit different, and potentially more positive, emotions. The present study raises awareness around student emotion related to societal responsibility as it can have implications for their experience and achievement in school.

The findings for RQ2 provide insights into aspects of engineering culture and curriculum with implications for how engineering is taught and represented. First, the findings suggest the importance of helping bridge the gap between engineering education and practice with realistic projects. Although projects are limited in their ability to replicate the scope and environment of professional practice, the inclusion of constraints can make the projects more realistic and support students in dealing with different aspects of design, such as economic, environmental, and social. The language around the framing of the project also carries weight it terms of whether the projects are viewed simply as an "academic exercise" and therefore "fiction." The disconnection between engineering practice and education is well documented [35], and the present study contributes an understanding of its role in students' emotion.

A second recommendation from the findings of RQ2 is to broaden the scope of professional and societal responsibilities in engineering through varied examples. The data indicate students had a narrow conceptualization of responsibility in engineering that centered around making sure the bridge or building does not collapse, which was based on the examples that were mentioned in the classroom. Although students discussed these examples as being cursory mentions in their

courses, case studies and examples of engineering disasters are the most common teaching method in engineering ethics education [2][4]. However, this approach has been criticized for focusing on individual actions and duties instead of societal issues and the environment in which engineers work [7] [36]. The experience of the students in the present study suggests the value of including broader examples, such as related to sustainability [37] and equity [5], so students develop awareness of the range of responsibilities within the engineering profession.

A third recommendation from the findings of RQ2 is to convey the importance of engineering without over-emphasizing the weight on individual engineers. The experiences of the students in the present study indicate that hearing about the importance of engineers, both in contributing to society and making mistakes that cost human lives, adds to the stress and fear they felt regarding their future responsibility. A dominant narrative in the culture of engineering education is the emphasis on individual decisions and actions, whether positive or negative, and their impacts [36]. This implication also reflects calls within the engineering ethics education community to move beyond individualist and microethical approaches to attend the context in which engineers work that affects their agency [7].

Conclusion

This research contributes to the small but growing body of work on emotion in engineering education, and it responds to calls for additional explorations of emotions through socio-cultural approaches and intersections with ethics [13]. It is important to acknowledge students' emotions and understand how engineering education itself might contribute to them. Emotions are an inherent part of the learning process and classroom environment, and an understanding of students' emotion related to their conceptualization of responsibility can support awareness and development related to engineering ethics education.

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