

# Reflective practitioners through design: Perspectives of second-year engineering undergraduate students

Rubaina Khan  
Ontario Institute for Studies in  
Education  
University of Toronto  
Toronto, ON, Canada  
rubaina.khan@mail.utoronto.ca

Philip Asare  
Institute for Studies in  
Transdisciplinary Engineering  
Education and Practice &  
Division of Engineering Science  
University of Toronto  
Toronto, ON, Canada  
philip.asare@utoronto.ca

Lisa Romkey  
Institute for Studies in  
Transdisciplinary Engineering  
Education and Practice &  
Division of Engineering Science  
University of Toronto  
Toronto, ON, Canada  
lisa.romkey@utoronto.ca

James D. Slotta  
Ontario Institute for Studies in  
Education  
University of Toronto  
Toronto, ON, Canada  
jim.slotta@utoronto.ca

**Abstract** Full Research Paper - Engineering students experience a wide range of learning practices through technical and analytical thinking and a process of reflection is needed to support them with their meaning-making process. In this study, we analyzed students' perceptions on the role of empathy in human-centered design thinking processes. The reflection assignment took on a learning community pedagogical approach which can help students gain nuanced and deeper understanding of empathy. By situating the design experience within a community of peers, there are increased opportunities for norming and exchange, shared strategies and resources, and a sense of collective progress. We explored how the diversity in the dispositions and experiences of students played a unique and major role in framing and shaping design problems and perspective-taking. This paper reports the findings through a qualitative content analysis of reflective essays written by students in a sophomore engineering design course offered in two semesters. Through such assignments, instructors and curriculum integrators can understand the different ways their students are experiencing the curriculum.

**Keywords**—*reflective practice, engineering design, empathy, curriculum innovation, learning communities*

## I. INTRODUCTION

Learning to design in undergraduate engineering is a higher-order mentality that brings in art abilities, scientific inquiry all of which is chaotic and seldomly mathematically elegant [1]. Engineering design as stated by Dym et al. [2] is: “a systematic, intelligent process in which designers generate, evaluate, and specify concepts for devices, systems or processes whose form and function achieve clients' objectives or users' needs while satisfying a specified set of constraints” (p. 2). This definition presents design as a deep learning process that depends on systematic, intelligent generation of design concepts and the understanding of disciplinary specifications that make it possible to realize these concepts. Fluency in one's profession requires students to have a deep understanding of the nature and demands of their profession [3]. This expectation then falls upon educators to know how to design and manage a learning environment that offers reliable forms of assessment that support the students' developing career identity as they experience the planned and enacted curriculum [4].

In this pedagogical research, we introduced a reflective assignment in a second-year engineering design course. The assignment asked students to reflect on the concept of empathy and how it relates to engineering design both from the perspective of their personal engineering design approach and the perspective of the larger engineering profession. In particular, prior to individual reflections, a studio or cohort-based community activity enabled students to be aware of others' perceptions of empathy and design as it relates to their profession. The community-generated knowledge was documented and was available to the entire class as a resource to make deeper connections to the concept of concern.

Through a thematic analysis, we found that students emphasized that when of the nature design course involved more on framing design problems, it allowed them to explore their identities as a designer. Students pointed out that perspective-taking was essential to understand the problem space in the course. Also, students reflected on the specific tools that they used to gain empathy and how that connected to the norms of the professional world. Lastly, students articulated complex understandings of empathy in their profession such as through team interactions, course objectives, and industry expectations. The implications of empathy in engineering entails a deep understanding of the engineering problem, including the values and perspectives of different stakeholders (e.g. the end users, design partners who may represent different sub-disciplines, geographic or cultural aspects of the project) is discussed in this paper. To support students' development of 21<sup>st</sup> century skills, frequent reflective moments are necessary for students to integrate their understandings of learning, experience, and purpose.

## II. LITERATURE REVIEW

In this section a high-level introduction to the concept of empathy in design and its development is discussed followed by the purpose of pedagogical approaches such as reflective practice and fostering learning communities.

### A. Design as the space for socio-technical thinking and skills

In engineering education, design courses tend to be the site where students often experience the praxis of technical and

socio-technical skills. Faulkner [5] emphasizes that effective engineering education needs the integration of “technical and social” (p. 351) elements, however, the technical dimensions are prioritized in both practice and education. Such shifts in attitudes and perceptions in the engineering profession requires engineers in practice to challenge their worldviews by taking on a critical approach to engineering design [6]. Therefore, engineering design courses can highlight the need for socio-technical skills by choosing design contexts where students must fully understand the history, political leanings, and forms of knowledge to identify purposeful design specifications [7].

Scholars in engineering education have asked design educators to involve stakeholders in students’ learning in different stages of the design process for students to be tuned to the stakeholders’ socio-economic, political, cultural, historical, and environmental dimensions of the context [8]. Mazzurco et al. [9] identified that interactions, particularly in community settings, with stakeholders can be passive, consultative and co-constructive. The authors implied that with higher levels of participation, such as in the co-constructive relationship, students experience better project outcomes and recognize the importance of socio-technical thinking. Hence, stakeholder interactions need to be carefully woven in design courses and may need resources to support students’ communication with the communities. Zoltowski et al. [10] showed that without scaffolds, students did not recognize the need for stakeholder collaboration. Such scaffolds include setting design statements in broader contexts that require students to depend on contextual; listening when interacting with stakeholders [7].

### *B. Role of Empathy in Design*

One of the core principles of design thinking is its focus on human values at every stage of the process and empathy for the people for whom you’re designing is fundamental to this process. Across the fields of design and education, the notion of empathy has been recognized as the starting point in the design process. The designer must develop a strong knowledge of and empathize with the communities they are designing for, often including the community’s voice in the form of scenarios, or even engaging community members in participatory design methods. Several techniques and tools have been developed to support an empathic design process [11], however many of these are time consuming and expensive making them tedious to use. Some recent studies have looked at other approaches (e.g., peer feedback, persona interpretations), but more work is necessary to understand the role of empathy within curricular design assignments, and ultimately to help educators add empathy as an element of their design assignments.

### *C. Empathy Development*

Empathy is a nuanced concept which can be categorized as a “construct, ability, skill, disposition, intellectual virtue” among other things [12]. Furthermore, the authors elaborate that thinking of empathy through a developmental lens, we can assume there are several stage models that provides frameworks for one to move from less to more advanced cognitive, social, or moral stage through several intermediate points.

Building empathy in the design process starts with making space for self-empathy. When students approach design by starting to reflect on the identities they bring into the

community, they go through the process of “noticing, centering, sensing, suspending judgment, intention setting and attending to self” which allows them to reciprocate by providing spaces for others’ experiences [13]. Instructors can provide students frameworks through which they can bring in their unique dispositions, knowledge of the communities they inhabit and their lived experiences. Exhibiting to students that their experiences and voices are valuable for the class community can make them eager to hear others’ worldviews and practices [14]. The power of setting such an ambience can allow students to be receptive to new understandings and empathetic to others [13].

### *D. Reflective Practice*

Reflective practice is more than thoughtful practice. Central to reflective practice is the assumption that the quality of our actions is not independent of the thinking we are able to do before and in the process of the action. It is an important human activity in which people recapture their experience, think about it, mull over and evaluate it [15]. Schön’s [16] notion of reflective practice was a reaction against an instrumental notion of teaching where the teacher is a technician implementing others’ knowledge in practice. McArthur-Rouse [17] stresses the need for the development of professional identity, and Booth et al. [18] believe that to enable the development of practice, individuals need to explore knowledge that is both tacit as well as explicit. Booth et al. [18] believe that a community provides a vehicle for the translation and transmission of tacit knowledge, thus aiding the development and understanding of expectations of the profession.

The development of reflective skills is central to students’ academic and professional development within a discipline [19]. The ability to reflect on one’s practice when confronted by a novel, unusual, or complex situation distinguishes expert practitioners from novices [16]. By providing reflective moments for students, the course can support their deep understanding of the nature and demands of their profession while also supporting their developing career identity. Also, these student reflections can serve as an ongoing instrument for evaluating the course and broadly the design spine, to promote continuous improvement and accountability.

### *E. Learning Communities*

In the past three decades, a body of research has investigated the learning community pedagogy in which students create knowledge and apply their shared resources in inquiry activities [20]. A learning community has been defined as “a culture of learning in which everyone is involved in a collective effort of understanding” [21]. Students bring diverse interests and expertise to the community and benefit by working collectively to build both individual learnings and community knowledge. Such an approach can include carefully designed inquiry activities that serve to advance (with guidance from the teacher) community knowledge through productive discourse [22]. Students engage in epistemic orientations (i.e., to the community pedagogy), in which they learn how to learn as a community and come to value the shared nature of artifacts and ideas. Design activities offer a compelling source of inquiry, for such a pedagogy, as they can draw consequently upon the knowledge base and support the processes of knowledge building [22]. This form of the curriculum also prioritizes diversity and democratic

forms of learning, student voice, giving students voice and ownership over what they want to learn and how they want to share it with others.

### III. METHODOLOGY

In this section, we discuss the the research context, a conceptual framework that supported the design of a studio exercise and reflective assignment, and the method of data analysis.

#### A. Research Context

This pedagogical research is situated in a sophomore engineering design course. The course is part of a sequence of design courses offered to the students in the program termed as the design spine. In the first two years, the entire cohort takes foundational design courses. In the final two years, the design experiences vary depending on the specialization the student has chosen. All students graduate with a capstone design experience. Each engineering design course in the design spine offers a new perspective and context for design. The frequent design experiences are aligned with the Canadian engineering accreditation board guidelines on engineering design curriculum.

In the course where this study is situated, the design opportunities are situated in a global context. The instructional team have various diverse cultural and educational backgrounds and use their extensive global network to gather design contexts that are current issues faced by urban and/or rural communities. This course was first offered in Fall 2021 and subsequently in the Winter 2022. Fall 2021 had 207 students and Winter 2022 had 301 students. Students were grouped into teams of five members based on results from surveys on learning and working styles. The teams assigned with a certain design opportunity were scheduled in the same studio (tutorial) for the entire semester. This arrangement helped with collating questions for our global stakeholders and give teaching assistants specialized cultural and contextual training.

The design opportunities were co-developed with global stakeholders and were presented to students in the form of design statements, visual media of the locales, and an opportunity to ask clarifying questions. The process of understanding the local context and culture required teams to do secondary research and engage in perspective-taking. Hence, we took this opportunity early in the semester to engage students in a conversation of empathetic design. We delivered lectures and studio activities to elicit awareness of our current situation and lived experiences which influence our ability to empathize with people and communities from other global and situational contexts.

#### B. Studio Activity and Reflective Assignment

In Figure 1, we developed a conceptual framework to create a collective and individual reflective experience. Engineering design experiences provide the platform to form professional identities, showcase disciplinary expectations and build socio-technical skills such as empathy for stakeholders (Khan et al, 2022). We want students to reflect on these aspects of their design experiences every academic year within the context of their design course. As the intention is to understand how

learning progresses within the design spine, the prompts to the reflective assignments will speak to the unique experiences that the students will have in any given academic year.

To support community building and leveraging on others' experiences and conceptualizations of the various constructs, prior to individual reflections, a studio or cohort-based community activity will enable students to be aware of others' perceptions of professional identity [23], disciplinary expectations [16], and socio-technical skills, for example empathy in design [24], as they relate to their profession. The document generated in these studios will be available to the entire class as a resource to make deeper connections to the concepts of concern during individual reflection.

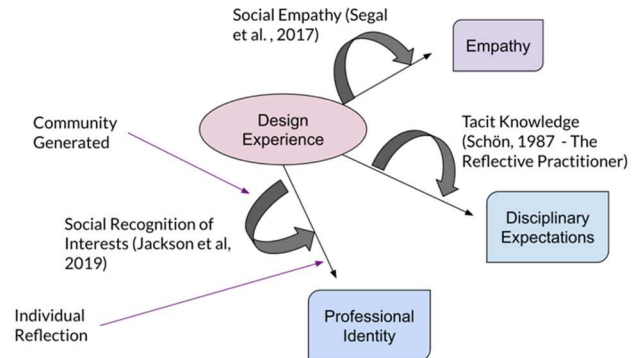


Fig 1. Conceptual framework for reflective assignments

Using the above conceptual framework, we designed a studio activity and an associated individual reflection. In the studio, we used case studies of development projects around the world which had the right intentions but failed due to lack of understanding of the local context [25]. The studio engaged students in deeper conversations about the role of engineers in global development projects and how empathy can be developed through engineering education. We used several prompts on polling software to capture individual and group generated perspectives. The ideas and thoughts from all studios (Fall 2021 = 8; Winter 2022 = 7) were gathered and arranged into a document. This community-generated document was accessible to the entire class and was linked in the individual reflection assignment statement.

Following the studio activity, students wrote a 1000-word reflection. The assignment statement asked students to reflect on how empathy played a role in their professional lives, what previous experiences allowed them to be empathetic, and how as designers would they develop skillsets to unpack and understand communities, locales, and societies at a deeper level. The assignment statement also indicated that the community-generated document can help students to see how their peers conceptualized empathy in the profession and could help them develop their unique perspectives on the topic. The assignments were graded by studio teaching assistants with formative feedback on reflective skills.

#### C. Qualitative Content Analysis

In this study, we developed a reflection experience for students which produced group generated knowledge and

reflective essays. These artifacts were analyzed using a content analysis approach to allow for themes to emerge that were unique to the research participants.

An approval from the university's ethics board was required prior to the study. We sent out an informed consent to all students in the cohort. We indicated that all material will be analyzed for research after the grades for the semester was submitted and data would be anonymized for all consenting participants. An average of 20 percent of the students consented for the research study. An arms-length person who was not part of the instructional team redacted any identifying information in the essays before the analysis took place.

Content analysis is a methodology that allows an inductive, and systematic approach for collecting, synthesizing, and generalizing qualitative data for the purpose of evaluating patterns in the data [26]. With a broad enquiry in mind, the researcher commences in understanding a particular topic area and further informs the collection of appropriate information about the topic. After the processes of data collection, patterns of deeper underlying interpretations are done with specific research questions by coding the data for meaning. These codes are refined to form categories that are then reported out as the themes that emerged from the analysis. In studying how people understand the world around them and how these perceptions relate to their social context, content analysis has proved to be a useful approach within a specific timeline, such as the semester in this research study. Using this approach, we were able to uncover the nuanced students' understanding of empathy as a designer, engineering professional, and as a team member.

For this study, a total of 78 essays written by students, who consented to the study, across both semesters. The reflections were analyzed using a qualitative analysis software, NVivo. The data was coded by two researchers independently with an inter-rater agreement of 86.312%. The coding process was guided by the following research questions:

1. How was empathy conceptualized by sophomore engineering design students?
2. In what ways, did students see being empathetic as necessary in engineering education?
3. What skillsets and experiences did students emphasize on being necessary to become empathetic designers in the future?

#### IV. FINDINGS

In this section, we present some of the themes that were seen through the analysis of the essays with supporting quotes.

##### A. Conceptualising Empathy

Students reflected on how they viewed empathy in various personal and professional situations. Most revolved around the idea that empathy is the human ability to share the emotions of others, without having directly experienced the cause of those emotions. From a professional perspective, students thought the engineer need to effectively understand the wants and needs of stakeholders, as well as have the ability to vicariously experience a stakeholder's thoughts and feelings. One student reflected on the role of emotion in empathy:

"Empathy does not have to be an emotional trait exclusively, but emotions are crucial to being empathetic, regardless of the context."

Several students reflected on how their peers defined empathy in their studio and cohort and offered their own unique conceptualizations. Some students emphasized that it was not just walking in one's shoes but walking with their stakeholders for a considerable amount of time. One student found empathy to expand their understanding and emotional response to the experiences and emotions of others. Some found distinctiveness in the process of being empathetic. Two students reflected on different distinctions:

"I consider empathizing as a branching-out process, first drawing on my prior experiences or knowledge of others' lived experiences, then envisioning how they are experiencing their situation."

"Upon reviewing definitions as defined by classmates, there is a similarity shared of the centralization around connecting with stakeholders and that it can be learnt. A difference observed is the minimal explicit recognition that empathy is a conscious practice."

##### B. Sympathy vs Empathy

Many students defined empathy and were particular to distinguish it from sympathy. One student thought it was necessary to be aware of the distinction. They articulated that with sympathy individuals tend to feel for others with only a limited understanding of the others' experience while, with empathy, there is a strong understanding of another's experience and instead of feeling 'for' the individual, one feels 'with' them. Some students reflected that sympathy helps you to understand a person's position without a strong emotional response to their experiences. Another student elaborated on the affective aspect of empathy as compared to sympathy:

"There is one main difference between empathy and sympathy, or simply accepting someone's perspective based on logical reasoning alone. It is the way we truly focus on the other person instead of ourselves and try to see things through their eyes, absorbing some of their emotions in the process."

##### C. Role of Empathy in Engineering Design

Several students reflected on the how empathy played a transformational role in engineering design. They highlighted that empathy in design is not merely the ability to effectively put oneself in the stakeholder's shoes. It is also the ability to envision how the design might impact others besides the stakeholder. Many students elaborated these ideas by anchoring on an example from the engineering world that are often case studies to highlight biases in the technology and how communities are excluded and harmed. Students identified several specific roles on how empathy informed different aspects of their design work. First, empathetic conversation clarified or determined the motivation for the design project and enabled genuine cooperation between the team and the client to create effective solutions. The importance of communication and research in empathetic design led designers to be aware of their biases and stereotypes and allowed for a change in focal lens. Second, students found that empathetic design actions led

to broadened framing of their stakeholder. A student addressed ableism in design here:

“It is very easy to overlook peoples with special needs, or special circumstances when designing a product and an empathetic approach would be reflect on the accessibility of the design choices.”

Similarly, another student chose empathy in their language choice:

“I was careful to use the word stakeholders, as opposed to “end user”, or “customer”. This is because I believe that we need to have the ability to show empathy towards all stakeholders, not just the end users of the product/design.”

Lastly, students identified empathy to improve the sustainability of their designs. One student thought that empathy into the design process can improve scalability by considering how communities will react and paying attention to various perspectives. Also, some students pointed out that empathy can aid engineering designers in identifying boundaries, outside of which introducing the technology may become inappropriate, unless the design is modified. This idea was articulated in one student’s reflection:

“Another facet of empathy is more reflective; it involves consideration of the impact and consequences of actions on others, by relating those impacts to those we may have personally experienced, or perhaps to even contemplate such an experience if we have not felt them ourselves.”

#### *D. Quality Engagement with Stakeholders*

Although most students highlighted the need of empathy in interacting stakeholders and understanding their needs better, many students reflected on the nature of their engagement with them. Students identified caveats in their understanding which helped them to prepare better for future engagements. One student shared their experience in a previous design project:

“Our initial meetings with the shelter were quick with little interest shown by the representatives. However, upon our team conducting significant research into stray cats, and gaining an appreciation of the situation and the shelter’s experience, we noticed greater engagement by the representatives who offered us access to their photo libraries, shelter documents and even a personal contact number. These gestures revealed that our team’s empathetic approach to the project was recognized by the stakeholders as genuine.”

In the event of several stakeholders, students felt designers must have the ability to show empathy towards all stakeholders but also to balance the empathy shown to all of the stakeholders. Also, some students experienced some stakeholders who are either reluctant or not able to articulate their needs to designers, as such through several empathetic interactions students were able to focus on a set of priorities that their stakeholders valued the most.

#### *E. Challenges*

Students defined empathy in unique ways and also identified challenges that they thought posed as an hindrance to being empathetic. Firstly, some students thought due to lack of

perceived professional explicit expectations of empathy, they thought it was up to the individual themselves to choose to pursue an empathetic approach. A quote to support this finding:

“While empathy is an altruistic trait that is essential for connection, there needs to be a willingness to act on it.”

One student thought that growing up in different cultural values often leads to biased assumptions about other societies. They bring this up when reflecting on how communities are conceptualized in different cultures:

“Living in the western world, I think we often forget the global situation of tightly knit community and family structures and how significant community situations can be in affecting individual actions.”

Students identified sources of bias and therefore regarded them as challenging when going through perspective taking of others’ situations. In these situations, many students identified the need to interact with their global stakeholders as a way of putting themselves in their shoes and form an empathetic connection. As interactions were limited with global stakeholders, students thought that biased assumptions were frequently made. These assumptions were blamed on privilege as noted here:

“I think many would agree that, growing up, we held on to self-centered attitudes and were not too concerned with the consequences of our actions, much less the sufferings of people subjected to complex global issues like poverty.”

“Unfortunately, abstractly designing for usability is not only untenable but counterproductive without understanding what our differently abled stakeholders consider usable. We were all able-bodied engineering students and that fundamentally influenced our epistemic position.”

Finally, students pointed out that although they recognized their team members’ diverse backgrounds to be an asset in understanding global issues, often, they were sources of dispute. Students identified that design decisions require compromise when establishing requirements and it got difficult to convene when members had opposing views. These opposing views were also identified when interacting with various stakeholders in the community that gave contradicting information.

#### *F. Metacognition*

Across all reflection assignments, students reflected on definitions of empathy, experiences from past design projects and lastly on how they saw further learning to develop empathy. As prompted by the assignment statement, students reflected on their growth from other design courses and the varying nature of empathy expected from them. Some reflected on their personalities and their learning styles that may have an impact on their empathetic encounters with stakeholders. One student reflected on their learning style identified in a personality survey from a previous design course:

“As a Driver [from survey], I tend to want to make decisions quickly. These traits, I believe, sometimes can impede me from incorporating empathy in my designs, such as in my [course name redacted] project initially. I believe that by having patience with team members/stakeholder, eliminating personal bias,

treating all ideas as valid, and understanding opposing arguments through conversation, I can further develop my ability to empathize.”

Many students used their reflective assignment to connect empathy and the engineering profession. Some students updated their personal engineering process that they had developed in their first-year engineering design course. Some students felt the engineering profession or education did not explicitly or frequently require them to exercise empathy:

“Empathy is not something I consciously do in my courses. Rather, it is often reflexive and can even feel too strong at times. I think these feelings give us the motivation to pursue causes that we believe in and persistently work towards positive change as engineers.”

## V. DISCUSSION AND FUTURE IMPLICATIONS

Empathy does not manifest in all design courses by the virtue of it being open-ended. The experience needs to be scaffolded, frequent, and carefully planned. The structure of the design assignment in the course provided deeper understanding of the scaffolds necessary for the community to engage in empathetic discourse. The design assignment unfolded over the entire course which allowed for design team members to work with other peers on different assignments. The trust in the community needs to be gained through purposeful activities and opportunities to work with several community members in meaningful tasks [27]. Therefore, during peer feedback, both community members who offer critical comments and the design team who receives them are comfortable and accepting due to the trust built early into the course. Hence, empathy for the global contexts can be generated and refined by the community – the studio in the case of this course.

Empathy development requires authentic and contextualizing experiences. Students need to feel the experiences are meaningful and empathy was necessary to understand and appreciate the context. Such practices help students connect perceptions and beliefs to technical design [28]. As many students alluded in their essays that different communities facing similar issues may require different design approaches and therefore contextual sensitivity is needed to understand nontechnical influences of the technology in unique settings.

Social recognition of peers’ ways of thinking especially socio technical thinking allows individuals to augment their thinking and authenticate their viewpoints. Such activities need to be repetitive to show value of collective knowledge building. As such, instructors can provide students with frameworks through which they can bring in their unique dispositions, knowledge of the communities they inhabit, and lived experiences. We noticed that students provided exemplars of empathetic design were often related to their research interests, lived experiences, and professional expertise. Therefore, exhibiting to students that their experiences and voices are valuable for the class community can make them eager to hear others’ worldviews and practices. The power of setting such an ambiance can allow students to be receptive to new understandings and being empathetic to others [29].

This study is among a select few that explores the concept of supporting empathy using a learning community approach. Adopting such an approach enables the class as a community to engage in empathetic discourse. A learning community pedagogy embraces grounding in the theme of the course while engaging openly in dialogue - making student voice an integral aspect of the experience. In this study, we provided the space in which students’ voice, their lived experiences, and positionality was an asset for design teams.

Further research must be done to establish the effectiveness in developing empathy with the help of the learning community. Therefore, we propose to conduct future research that seeks to explore the question: how does a learning community pedagogy impact students’ generation of empathic solutions to engineering problems and the development of empathy? We will collect students’ design briefs and conduct content analysis to examine if students demonstrated evidence of effectively engaging in the empathy techniques and feedback provided by peers and generating empathic solutions to engineering problems. In subsequent offerings we propose that design teams maintain a reflection journal to reflect on how their peers’ empathic comments and identities are playing a role in shaping their designs, challenging their biases, and expanding their empathic horizons [30].

## VI. CONCLUSION

In this pedagogical research, we found that engaging students in empathetic discourse with their peers resulted in deeper understanding of the role of empathy in the engineering profession. Such scaffolds are necessary for students to engage in self-awareness and instrumental in any design work particularly in global contexts. We demonstrated that using reflective essays, students can exhibit their meaning-making process and articulate lifelong learning skills necessary to become the next-generation engineers.

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