THE IMPACT OF INDIGENOUS KNOWLEDGES AND PERSPECTIVES IN ENGINEERING EDUCATION: ONE STUDENT'S STORY

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Abstract – A qualitative narrative study was designed to examine the impact on students' learning when an Elder came to speak to students in a *Technology, Society and the Future* course in the Price Faculty of Engineering at the University of Manitoba. This study accounts for one student's story as heard through an open-ended narrative interview facilitated by a team of researchers, and re-storied into a problem-solution narrative structure. The preliminary findings highlight the impact of the Elder's teachings on the student, the importance of Indigenous People's Knowledges and perspectives in engineering education, and the importance of making space for students to reflect on these learnings.

Keywords: Indigenous Knowledges, engineering education, student learning, narrative research, problem-solution narrative structure

1. INTRODUCTION AND MOTIVATION

Engineering surged in Canada in the mid-1800s, using innovation and mathematics to design and develop a modern Canada [1]. At a time when engineering schools became increasingly prevalent, and curricula emerged, the voices of Indigenous Peoples were left out of the conversation. Foundations of knowledge held by the Indigenous Peoples, including their holistic focus on observation, experiential learning, and oral storytelling as central ways of knowing, were excluded [2]. The prevailing Western knowledge system dominated the basis of engineering across Canada.

Residential Schools were a mechanism by which this Western knowledge domination was achieved. The residential school system was implemented in Canada in the late 1800s and was in operation for over 100 years. It worked to remove pre-existing Indigenous culture from over 150,000 First Nations, Inuit, and Metis children [3]. Indigenous children were forcibly removed from their homes, stripped of their native language, and indoctrinated into the Euro-Canadian ways of living through Christian religious affiliation [4]. The Truth and Reconciliation Commission (TRC) of Canada is part of Canada's work to

make amends for the systematic genocide of Indigenous Peoples [5].

Out of the TRC's work came 94 Calls to Action for Canadian people. Within Education for Reconciliation, Action 62 calls upon the federal, provincial, and territorial governments in consultation and collaboration with survivors, Aboriginal Peoples, and educators to "provide the necessary funding to post-secondary institutions to educate teachers on how to integrate Indigenous knowledges and teaching methods into classrooms" [5]. Moreover, section 63(iii) calls upon the Council of Ministers of Education to "build a student capacity for intercultural understanding, empathy, and mutual respect" [5]. This is essential to assure that Indigenous Knowledges and perspectives are being taught to university students as a requirement for their post-secondary education.

Specific initiatives within the Price Faculty of Engineering at the University of Manitoba (UofM) have focused on ways to better integrate shared knowledges for engineering education. One initiative is in the *Technology, Society and Future* core engineering course. Over the past few years, an Indigenous Elder has been invited to speak with students about the impact of engineering on Indigenous communities, and share Indigenous Knowledges, culture, traditions, and belief systems. Knowing how students' learning is impacted by this experience will help inform further representation of Indigenous ways of knowing and being in engineering education.

In this paper we present one student's story from a larger narrative research study designed to examine how Indigenous Knowledges and perspectives in engineering education impacts students' learning. The larger study examines, *How do Indigenous Knowledges and perspectives impact students' learning in an engineering course?* The findings will inform engineering educators how to move forward with this initiative, and inform further efforts to make space for Indigenous Peoples, Knowledges and perspectives in engineering courses and curricula.

2. BACKGROUND

There is not a lot of research in engineering education that explores the opportunities for students to learn from and engage with Indigenous Peoples and Knowledges [7]. Research in social work and education on this topic is more extensive and acknowledges how the structure, values, and epistemological foundations of Western academics do not leave space for Indigenous Knowledges to be seen as valuable or relevant [8][9][10].

Although not specific to Indigenous culture Handford et al. (2019) reveal a tendency for intercultural communications taught in engineering education to arise from a differentialist and essentialist perspective [11]. A strong focus on differences between nations and nationalities prevents an understanding of context-specific localities and intersecting identities of individuals, and supports a deficit-based approach to learning [11]. These prescriptive approaches can pose barriers to learning from different cultures and lead to stereotyping and poor collaboration [11].

Findings from a study by Guzman et al. (2021), found that if medical faculty integrated concepts of cultural competencies “closely related to the practice of medicine”, students were more receptive to learning [12]. Furthermore, faculty have had more success teaching cultural competencies with experiential learning environments [12]. Instructor facilitation of reflection and discussion, and encouragement to “embrace complexity over reductionism” can help students learn to view different cultures and society from a less mechanistic, dominant and modernistic perspective [11].

Bennett et al. (2018) state a faculty relationship with Indigenous community members is a critical factor for successfully teaching engineering students about Indigenous Peoples and Knowledges, and requires time, resources, organizational support and leadership [13]. To be culturally responsive requires “a willingness to learn, to make mistakes and to demonstrate openness to new ways of knowing, being and doing” [13]. Kennedy et al. (2016) strongly recommend that local Indigenous community members are connected with engineering educators who intend to teach engineering students about Indigenous Peoples and their knowledges in order to develop genuinely curious mindsets in students [6]. They emphasize that for Indigenous Knowledges to have a meaningful presence in engineering education, engineering culture needs to shift from viewing Indigenous Peoples and cultures as “less than” and in need of saving to a mindset of “deep respectful curiosity” [6].

3. AUTHORS' POSITIONALITIES

The first author, George, is Coptic Orthodox Christian born in Cairo, Egypt. At the time this research was conducted, he was a 5th year undergraduate Biosystems

Engineering student at the UofM, working on this research for his undergraduate thesis project. George began this research not knowing much about Indigenous cultures and history. Thereby, at the outset of this study, he enrolled in the Indigenous Canada Massive Open Online Course (MOOC) with the second author, which is a 12-lesson course providing foundational knowledge of Indigenous Peoples in Canada, offered by the Faculty of Native Studies at the University of Alberta. They also viewed *Reconciling Ways of Knowing* Forums, which are Indigenous Knowledge and Science forums hosted by The Reconciling Ways of Knowing society in partnership with Turtle Lodge Centre for Indigenous Education and Wellness, the Indigenous Leadership Initiative, and the David Suzuki Foundation [14]. These forums provide insight on how Western science is failing people, and there is a desperate need for a new perspective. The course and the forums were very important as they emphasised how little the first author knew about Indigenous Peoples in Canada despite having had his middle school, high school, and post-secondary education in Winnipeg. The first author also had the opportunity to learn from Elder Norman Meade, the Elder-in-Residence in the Price Faculty of engineering. This experience helped George form a personal connection in his quest to learn from Indigenous Peoples about Indigenous Knowledges and perspectives.

Victoria is 3rd generation Canadian of European descent and currently resides in Treaty 6 Territory, and Homeland of Métis Nation Region 4. She is passionate about learning from Indigenous Peoples and finding ways to be an ally in engineering education. She mentored George through his undergraduate thesis research.

Jillian is a white settler woman who grew up on Treaty One Territory and in the Homeland of the Métis Nation. She is a mother, wife, daughter, sister, and aunt. She is involved in this work because she knows it is our legal, moral, and ethical responsibility to decolonize Canadian educational institutions and systems, and make equitable space for Indigenous Peoples and their ways of being and knowing. She was George's undergraduate thesis supervisor.

Afua is an African woman, a Post-Doctoral Fellow and Engineer-in-training living on Treaty One Territory. She is traditionally connected with the Kwahu Peoples of Ghana. She is in this space because she has learned that a deeper relationship occurs when we learn about others' journey, view the world through their lenses and find a common place to thrive together.

Randy grew up in Treaty One Territory and the Homeland of the Métis Nation and has multiple positionalities. His father is a German immigrant who came to Canada shortly after the end of World War Two. Through this lens Randy is sensitive to some of the barriers that newcomers face when they arrive in Canada. On his mother's side he is proudly Métis, counting among his settler ancestors some of the first colonizers that came to

Manitoba, and to Canada. Through this lens he is keenly aware of both the settler and the Indigenous realities. He is a first-generation University graduate and knows of the difficulties that this path involves and the numerous barriers to education that Indigenous people face. He is also a son, nephew, uncle, and most importantly a father and a husband. As a white-appearing Métis male, he is profoundly aware of his privilege and is determined to leave the world a better place than it was when he entered it.

4. METHODOLOGY

A narrative research study was designed to examine the impact on students' learning after the integration of Indigenous Knowledges in the *Technology, Society and the Future* course, a core engineering course offered in the Price Faculty of Engineering at the UofM. This methodology was chosen to honour the importance of story to Indigenous ways of knowing and being [15]. Narrative research "offer[s] insights about the world and/or people's experiences of it" [16], and qualitative research examines individual's experiences in depth, using words and lived experiences [17]. A problem-solution narrative approach was selected, where the raw data is analyzed and retold using events and the five plot elements of a story [18], as this structure was reflective of participants' stories.

For the research presented in this paper, one student participated in an open-ended narrative interview (online) facilitated by one graduate and one undergraduate student, and supervised by one faculty member (the first three authors on this paper). The interview protocol was designed to guide the participant to tell their story of the impact on their learning of Indigenous inclusion in the course. There were two areas of questions developed. The first area was designed to learn general information about the participant, such as their engineering department. The second area was designed to centre on the experiences the participant had during the Elder's class discussion in the *Technology, Society and the Future* course.

The interview was recorded, and Dictate was used for transcription. The analysis focused on the participant's perspectives on the impact of integrating Indigenous Knowledges and perspectives in engineering education, retold using the problem-solution narrative approach. Once the narrative was complete, it was sent to the participant "to negotiate meaning" [18] and ensure that the participant agreed that their story was being told and their pseudonym represented them.

4.1 Conceptual Framework

The problem-solution narrative approach was used as the conceptual framework for this study. The participant's narrative emerged and was re-storied through the identification of their chronological experiences and a problem they were encountering. Events, the turning point,

and the resolution were identified. An outline of this process is illustrated in Figure 1.

Fig. 1. Sequencing the events into the problem-solution narrative structure.

4.2 Limitations

Narrative research is a deep and interactive process between researcher and participant. It requires the researcher to develop a firm understanding of the participant's story, which normally happens by meeting with the participant several times over the course of the research process. The interview process for this thesis was granted approval near the end of the project's deadline, limiting meeting with the participant to one time. This time constraint prevented the level of immersion encouraged in narrative research. To account for this, we had a team of three interacting in the discussion, with one member listening actively. We encouraged the participant to unpack comments, thoughts or experiences using several prompts, and used member checking to ensure the participant's story was being heard.

4.3 Cultural Sensitivity and Protocol

Throughout the research process important measures were taken to insure appropriate cultural sensitivity. Elder Meade was offered tobacco and asked to help the first three authors begin this research in a good way. He spoke to the first three authors about the significance of the Medicine Wheel. We worked to be inclusive throughout this process in how we think about and represent our understandings. We acknowledge that we are new to these learnings, are non-Indigenous, and ask for understanding and patience as we work in this space.

4.4 Ethics

Approval for this research was obtained from the UofM's Education and Nursing Research Ethics Board and from the UofM's Office of Institutional Analysis.

5. FINDINGS

In keeping with the narrative research methodology, Lisa's story is told here:

Lisa (a pseudonym) is an engineer who graduated from the Price Faculty of Engineering. She was influenced to learn about Indigenous Peoples by more than just her engineering education. Her mom was a teacher and motivated her to learn about Indigenous Peoples in Canada. Lisa had a job as a host at the Canadian Human Rights Museum and recalled an influential art exhibit called "The Witness Blanket" that communicated the history and lasting impact of Residential Schools on Indigenous Peoples across Canada. She recalled spending a lot of time in the gallery. She would look at the objects and think about what happened in residential schools.

When she was an undergraduate engineering student, Lisa volunteered for "Alternative Reading Week" a University initiative, where she worked with Two-Spirited People of Manitoba Inc. to search the city for sites for ceremony and prayer for the Indigenous community. In the middle of her engineering program, Lisa enrolled in the *Technology, Society, and the Future* course. She remembered a class when she was in the presence of an Indigenous Elder. She spoke about this as a rare opportunity. She remembered not knowing how to act and feeling uncomfortable but safe in the classroom and formatted discussion. She remembered learning about local Indigenous communities impacted by the provincial Hydro system. This struck her, as she hadn't recognized until that point the impact her electricity consumption had on communities that were not her own. She didn't have any close friends in the class and didn't speak about this experience with her peers. She continued on with her engineering degree.

Nearing the end of her engineering program, in the middle of her final capstone course, Lisa had an important realization. She listened to a lecture by Randy Herrmann, Director of ENGAP, who spoke about Indigenous technologies. It was in that moment when she connected Indigenous Peoples and engineering. Lisa heard about examples of innovation from Indigenous Peoples throughout history and realized that Indigenous Peoples have been engineers for millennium. She recollected all her past learning about Indigenous Peoples and the importance of this knowledge for her future professional practice. She was sorry that she hadn't seen this connection before this moment, but was grateful for the moment and inspired to keep learning.

Lisa did not work immediately following graduation and used this opportunity to enroll in Indigenous Canada's Massive Open Online Course (MOOC) offered by the University of Alberta. She was driven by her interest to know more about Indigenous history in Canada. She said it was an intense course, but she was happy to do it. She didn't realize at the time the benefit it would have in her future employment.

When she accepted a project management role in industry, she was initially unaware of the direct involvement she would have with Indigenous communities. Once she realized that she would be doing work with Indigenous communities she was excited to have another opportunity to broaden her knowledge and took an Indigenous awareness training workshop through work. She thought something like that would be a good training opportunity for all engineering students, as it was about three hours and she felt it would be manageable for all students. She stressed the importance of engineers/engineering students learning about Indigenous cultures and understanding specific community struggles when working alongside Indigenous communities in industry. She was grateful for the background knowledge she had built. She found she was much more passionate about the projects she was working on when she had specific knowledge and understanding about the Indigenous community she was working with.

Considering her own experience as an engineering student, and presently working in industry with Indigenous communities, Lisa felt compelled to advocate for the importance of Indigenous Knowledges in engineering education. She felt strongly that as a Canadian, and more specifically as a Manitoban, everyone should know why Canada is the way it is, and the history that has built this country. As an engineer working in Canada, collaboration with Indigenous people is going to happen. Therefore, knowledge about Indigenous Peoples is important and should be implemented in a university setting. She believes that space should be made in every engineering course to discuss the impacts of engineering on Indigenous Peoples, communities, and cultures.

6. DISCUSSION

Lisa's story is represented in the problem-solution narrative framework to visualize the important events of her story, and how those events resulted in a turning point and resolution (see Figure 2). Lisa's 'problem' was that she wanted to learn more about Indigenous culture throughout her adult life. She experienced several significant events leading to an influential turning point. Events 1 (Mother's influence) and 2 (The Wisdom Blanket at the Human

Fig. 2. Lisa's story as represented in the events into the problem-solution narrative structure.

Rights Museum) occurred before her engineering education, while events 3 (volunteering with Two-Spirited People of Manitoba for Alternative Reading Week) and 4 (Elder Meade's teaching during the *Technology, Society and Future* course) happened within her engineering degree.

The second of these university encounters occurred in her *first* encounter in the engineering program, specifically through the *Technology, Society, and the Future* course, the focus of this research study. Lisa recalled a feeling of discomfort being in the presence of Elder Meade, which stemmed from her lack of knowledge on how to act or approach Indigenous Elders, and her lack of experience with Indigenous Elders. This is significant. This experience was so rare for Lisa and such an anomaly in the program, that she was uncomfortable. Engineers work to serve the public. Eighteen percent of Manitoba's demographic identifies as Indigenous [19]. As an engineer in Manitoba, one will (and should) work with Indigenous Peoples and/or Indigenous communities at some point in their career. As

engineers in Manitoba, we have a responsibility to know about, and know how to respectfully and responsibly work with, the population being served. This cannot exclude the 18% of the population identifying as Indigenous.

Despite her feeling of discomfort, Lisa was able to listen to Elder Meade, and learn from him. She learned the impact that Westerners have on Indigenous communities, and felt a new sense of responsibility in knowing how, for example, her consumption of electricity affects Indigenous communities, an understanding she did not have prior to her experience with Elder Meade.

Lisa was uncomfortable during Elder Mead's lecture, but without this event, and arguably, without the events in Lisa's narrative prior to this – her mother's influence to learn about Indigenous Peoples in Canada, her interaction with the Wisdom Blanket at the Human Rights museum, and her volunteer experience with Two-Spirited People of Manitoba – Lisa may not have had the motivation to learn through her discomfort. As a result, Lisa may not have

experienced her pivotal turning point when she heard Randy Herrmann's lecture in her final year capstone course. In Randy's lecture about Indigenous technologies, Randy discussed the technological advances that Indigenous Peoples have provided society, such as the Incan roads, Incan suspended bridges, and Indigenous farming strategies, such as the Three Sisters – the symbiotic planting of beans, corn and squash. It was during this lecture that Lisa realized explicitly, for the first time, that Indigenous Peoples have been engineers for millennium. It struck her how she had almost completed her whole engineering degree and had never learned this. She was really bothered by this realization, and came to understand in that moment how important it was for engineering students to learn about Indigenous engineering.

Due to her turning point, Lisa resolved to keep learning about Indigenous Peoples in Canada. After her graduation, she enrolled in the Indigenous Canada's MOOC (see *Authors' Positionality* for more details on this course). This ultimately helped her to prepare to work with Indigenous communities in industry. The outcome of Lisa's story is that she worked to learn more about Indigenous Peoples in Manitoba and Canada to be a better citizen and engineer. Her desire to see change within engineering education is another outcome, which ultimately led her to voluntarily participate in this study. Lisa's desire to affect change in engineering education is directly connected to the problem that was originally hers – wanting to learn more about Indigenous Peoples. She has since come to recognize her problem as a problem for other students in engineering education that needs to be rectified.

For Lisa, it was the impact of multiple exposures to Indigenous Knowledges that lead her to be motivated to continue learning about Indigenous People. If Lisa did not experience events 1 and 2 before her time in engineering events 3 and 4 might not have had a significant impact on her learning. She may not have had the motivation to learn about Indigenous Peoples that has extended into and influenced her career as an EIT. Lisa's experiences were only possible because two instructors made space for Indigenous Peoples – Elder Meade and Randy Herrmann – in their courses. Lisa's story highlights the importance of hearing from Indigenous Elders, Knowledge Holders and experts at multiple levels throughout an engineering degree. It also demonstrates the importance and impact of grassroots initiatives in engineering education.

However, the initiatives experienced by Lisa are not enough. As discussed, due to the TRC Calls to Action and our responsibilities as citizens in Canada, and due to our responsibilities as engineers to the public, engineering educators have an obligation to bring Indigenous Knowledges forward in engineering programs. Lisa shares that she had only two opportunities to learn about Indigenous Knowledges throughout her whole engineering degree, and only made the connection between engineering

and Indigenous people in her final year of engineering. This is two hours of approximately 6,500 instructional hours of undergraduate engineering education, a total of 0.03% of Lisa's formal engineering education. It is clear that hearing only two hours of Indigenous perspectives in a whole engineering degree is evidence that Indigenous voices continue to be left out of engineering education [2].

Another important consideration from Lisa's story is that these two hours of Indigenous teachings were not followed by time for Lisa and her peers to reflect and discuss what was learned – either formally in class, or informally after class. Lisa told us that she didn't have any close friends in the class and didn't speak about this experience with her peers. She continued on with her engineering degree without having the opportunity to explore how these teachings related to her personally, and to her future professional life as an engineer. The understanding of the importance of reflexivity in engineering education is growing. As described by DaMaran, Pearlston, and Mattucci [20],

In an engineering context, reflection has helped students connect what they have learned in the classroom to job knowledge and skills, allowing them to better apply their knowledge to real scenarios. Reflective practice has also shown to be an important skill for practitioners, such as engineers, in recognizing and understanding learnings that come out of experiences.

Other students may or may not have been as impacted as Lisa, but given the chance to reflect and further discuss these teachings may have encouraged more students to experience a greater and more lasting impact from this experience; a chance to really hear the missing Indigenous voices in their engineering education.

Although colonization oppressed Indigenous Peoples in Canada, the goal of having Indigenous Knowledges present in engineering curricula should not only emphasize this adverse history and the negative impacts but also highlight Indigenous resilience and the powerful and important Knowledges and perspectives that Indigenous Peoples can bring to engineering education and the engineering profession. As described by Kennedy et al. "by valuing Aboriginal perspectives and replacing the perception of cultural inequity with a deeply respectful curiosity, it is possible to reposition Aboriginal people and their knowledges as equal with, and simultaneously different from, other cultures and knowledges" [6]. Engineering educators need to recognize that Indigenous Knowledges, Western knowledge, and engineer knowledge are different, but each equally valid to educate future engineers [11]. Missing education in one area disadvantages engineering students. The benefit of valuing Indigenous Knowledges as equal to Western and engineering knowledge teaches engineering students to consider engineering holistically, highlighting the interconnectedness of life taught through Indigenous

Knowledges [21]. Ultimately, emphasizing Indigenous Knowledges and perspectives will educate engineers who are better equipped to practice engineering in Manitoba, Canada, and across the world.

7. CONCLUSIONS

Lisa's story is one example of the impact of integrating Indigenous Knowledges and perspectives in engineering education on one engineering student. For Lisa, Elder Meade and Randy Herrmann's teachings increased her desire to learn more about Indigenous Peoples in Canada. Lisa's story demonstrates that efforts to make space for Indigenous Peoples in engineering education have impact. However, more space is needed for Indigenous Peoples in engineering education to ethically educate future engineers working in Manitoba, and Canada. As engineering educators, we have a professional responsibility to make space for Indigenous Peoples and their Knowledges, perspectives, values and experiences in engineering education, as well as a responsibility to create a learning environment where these learnings can be deeply felt and learned by all engineering students. This will be achieved by giving time for Indigenous Peoples and their Knowledges and perspectives in engineering education, and guiding engineering students to reflect on, engage in dialogue and relationship with, and ask questions of Indigenous Peoples. Overall, to meet the TRC's Calls to Action in education and our professional responsibilities as engineers, we must not only integrate Indigenous Knowledges and perspectives in engineering education, but we must validate Indigenous Knowledges as equal with Western and engineering knowledge within engineering curricula.

The work presented in this paper is one story in a more extensive narrative research study that is designed to learn about the impact on engineering students' learning as they experience Indigenous Knowledges and perspectives in their engineering education. It is not expected that all other engineering students will have the same experiences and views as Lisa. However, Lisa's story shows us that even the smallest efforts can have great impact. Thus, we move forward with this work, hopeful that it is having some impact, but knowing that there is much more work to do.

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