Transforming Paradigms through a Novel Transdisciplinary Design Build Course: A Case Study on Engineering and Architecture Students' Learning Impact at a Canadian University in Partnership with Shoal Lake 40 First Nation

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Abstract

The research presented in this thesis focuses on the learning impact of students' participation in a novel transdisciplinary design build course offered by the faculties of engineering and architecture at the University of Manitoba in partnership with Shoal Lake 40 First Nation (SL40 FN). Transdisciplinarity brings different people and their respective knowledges and worldviews together to address a common goal/challenge, often within a sustainability context. In this course, the instructors and Indigenous community partners aimed to transform the way architecture and engineering students are educated to design and build collaboratively across disciplines and cultures. A qualitative intrinsic case study employing cultural-historical activity theory (CHAT) and the researcher's social constructivist perspective narrates the learning journeys of six non-Indigenous students in the design build course. Participant interviews, portfolios and course field notes were analyzed. CHAT activity systems were generated to analyze students' learning in seven key activities in the course: the (1) historical context motivating the course provided on the first day, (2) cultural teachings from Elders, (3) community site visits and participation in ceremonies, (4) conceptual to final design, (5) Freedom Road Powwow, (6) prefabrication of design, and (7) onsite build. These activities were examined to better understand how the students navigated boundaries of (i) disciplinary practice (engineering and architecture), (ii) design actualization from theory to 3D, and (iii) relationship-building and collaboration with the Indigenous partners. Students' learning at the boundaries of discipline, design, and culture displayed paradigm shifts as pre-existing stereotypes, prejudices, knowledge gaps, and embodied ways of knowing were challenged to create pathways of perspective, communication, practice and identity formation supportive of interdisciplinary and intercultural knowledge exchange and relationship-building. The findings

from this research demonstrate that the SL40 FN Design Build course promoted epistemic diversification in the mentalities and hearts of the student participants who gained a greater knowledge and value of the respective discipline and Indigenous culture.

Little research has been published on higher educational transdisciplinary environments teaching engineering and architecture students to work with Indigenous community stakeholders. The research presented in this thesis aims to provide engineering and architecture educators and leaders with information on how project-based transdisciplinary courses can help prepare students to work on real-world complex challenges across disciplines in ways that constructively and respectfully navigate fragmented practices and relationships between diverse peoples and epistemologies resulting from the colonialization of Canada and as currently present in national and global sustainability challenges.

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Forward

It is important that the readers of this thesis research focused on students' learning in the Shoal Lake 40 First Nation (SL40 FN) 2019 Design Build course, are first acquainted with the prior two years of the authentic relationship-building work between Shawn Bailey, Roxanne Balan (previously Roxanne Greene), and SL40 FN community members. The facts of their relationship-building process will be briefly explained. Educators considering to provide similar course offerings for their students are reminded of the time and commitment educational institutions must undertake to work with First Nation communities in good ways. The authentic relationships developed from such commitments are essential and foundational for educational opportunities such as the transdisciplinary design build course explored in this research.

In Fall 2017, Shawn Bailey received his first teaching assignment, an architecture design studio, with the University of Manitoba. This architecture design studio was inspired by the Architects Without Borders Canada (AWB) Indigenous Housing Canada Ideas Competition 2017, to which students submitted their designs. Early into the studio, Shawn Bailey heard news of SL40 FN members presenting on their community's housing initiatives at the University of Manitoba. He approached Roxanne, a presenting community member and councillor, to discuss their work. Shortly after, Roxanne invited Shawn Bailey and his students to SL40 FN for a tour to help the students understand an Indigenous community context for their design work. At the time, Freedom Road was incomplete, and Shawn and his students took the barge into the community. The studio visited SL40 FN three to four times throughout the Fall 2017 semester. Members from the SL40 FN community came to the University of Manitoba to attend students' final presentations and provide feedback.

In anticipation of completing Freedom Road, Roxanne and other community members invited Shawn Bailey and his next studio course to assist the community in dreaming of infrastructure and development opportunities now feasible with road access into the community. Indigenous and non-Indigenous architecture students participated in the studio. Motivated by the learning that traditional ceremonies were once banned in First Nations communities, one student explored the design potential of a Powwow Arbour. At the end of the studio, SL40 FN community members once again attended the student's final presentations on campus. After the course, Shawn Bailey received a letter of intent from a community member asking if Shawn's next studio could focus on advancing the Powwow Arbour design. Shawn agreed, and in the Fall of 2018, he returned to the SL40 FN community with his studio to work on the design of the Powwow Arbour and the ceremonial grounds.

After working together for two years, Roxanne Balan and Shawn Bailey ideated their next project. They applied for and received the University of Manitoba Indigenous Initiatives Fund to financially support the 2019 SL40 FN Design Build course that is the focus of this research. The three architecture studios conducted in 2017 and 2018 facilitated relationship-building between Shawn Bailey and Roxanne Balan and other community members, who then played key roles in the 2019 SL40 FN Design Build course.

Chapter 1: Introduction

Scholars and non-academic organizations voice a need for epistemic diversification in education for sustainability (Parr et al., 2022; Wals & Jickling, 2002; Spencer et al., 2018). Such epistemic diversification is a fundamental shift in the higher education system, which currently prioritizes disciplinary knowledge with overarching institutional structures and social norms that inherently value certain domains of knowledge over others. Within Canada, especially over the past eight years due to the Truth and Reconciliation Commission and the 94 Calls to Action (TRC, 2015a; TRC, 2015b), the general public has experienced an increased awareness of how certain groups of people and lands have benefited at destructive costs to others. In other words, awareness of the negative externalities of Canada's colonialism nation-building and capitalistic economic activities are increasing. Identifying and including marginalized knowledge systems, for example, the feminine, BIPOC (Black, Indigenous, and People of Colour), people with diverse abilities, neurodivergent people, 2SLGBTQI+, and the Lands and natural resources we depend on for survival, require more than correcting limiting mindsets and actions; it requires opening up to the value of the inherent knowledges embodied in these groups, recognizing that the sustainability challenges we face today are intertwined and interdependent of all beings' epistemologically diverse contributions.

The research presented in this thesis work focuses on a novel transdisciplinary design build course in the faculties of engineering and architecture at the University of Manitoba in partnership with Shoal Lake 40 First Nation (SL40 FN). The course attempts to respond to capitalism and colonialism's negative externalities by expanding students' mentalities and skills to work collaboratively across diverse perspectives and epistemologies. This chapter begins by introducing the course partner, the community of Shoal Lake 40 First Nation. Then a vignette,

adapted from Perry (2016), presents the history of the design and build of the Winnipeg Aqueduct, which exemplifies how a local western civil development project rooted in colonialism and capitalism negatively impacted the Shoal Lake 40 First Nation community. This vignette stories the legacy mentalities and practices of capitalism and colonialism in infrastructure development that the SL40 FN Design Build course responded to, contributing to sustainability and decolonization movements. Transdisciplinary approaches to teaching and learning at the post-secondary level require collaboration between differing epistemologies and have been found to support change toward sustainability and conciliation (Edmunds et al., 2013, Riley et al., 2006, Macintyre et al., 2021; McGregor, 2007). The research presented in this qualitative case study contributes to this body of literature. It has been designed to explore and describe the impact on students' learning through their participation in the transdisciplinary Shoal Lake 40 First Nation (SL40 FN) Design Build course utilizing cultural-historical activity theory (CHAT).

Shoal Lake 40 First Nation: General Information

Shoal Lake 40 First Nation is a First Nations reserve with a population, as of September 2019, of 655 Ojibway (Ontario Saulteaux) peoples, with nearly one-half of the members living on the reserve (Shoal Lake 40 First Nation, 2021a). The Ojibwe are a specific group of people from the larger cultural group of the North American Anishinaabe community (Horton, 2017). The First Nation reserve straddles the Manitoba and Ontario Border in the Eastman Region of Manitoba and the Kenora district of Ontario (Shoal Lake 40 First Nation, 2021a). It is approximately 130km East of Winnipeg (Barrera, 2018). Shoal Lake, Indian Bay and Snowshoe Bay are the waters surrounding the community (Shoal Lake 40 First Nation, 2021a). Evidence of Anishinaabe ancestors at Shoal Lake dates back to 10,500 BCE (Shoal Lake 40 First Nation,

2021b). The nation is a member of the Bimose Tribal Council and the Grand Council of Treaty 3 (Shoal Lake 40 First Nation, 2021a).

The Design and Build of the Winnipeg Aqueduct: A Historical Vignette

The Canadian federal government, established in 1867, reorganized Indigenous access and rights to land and resources, including water, and in 1876 cemented them into law by passing the *Indian Act* (Perry, 2016). The Indian Act mechanized Indigenous peoples' mass displacement from urbanizing city centers to rural reservations and settlements in the late ninetieth and early twentieth centuries. Indigenous peoples include the First Nations, Inuit and Métis peoples. Political leadership used the discriminatory Indian Act to exercise control over Indigenous peoples and the land and resources they depended on for survival to re-affirm European cultural dominance (McCauley & Matheson, 2018). Like other western cities, Winnipeg became a non-Indigenous space and incubated politically seeded racism towards anyone other than white Europeans (Perry, 2016). These governmental and societal actions of oppression and marginalization encultured how engineers and city planners viewed and acted towards Indigenous peoples in their professional work.

As the population of Winnipeg grew from the steady arrival of European settlers, reliable access to safe water for consumption, household, and business needs became an increasing challenge (Perry, 2016). Water supplied from the Red River led to public health crises of typhoid outbreaks, and hard water from the wells damaged the boilers of machines prized for economic development. One of the most noted is the steam engine used to build the Canadian Pacific Railway, which further facilitated the mass mobilization and displacement of resources and Indigenous peoples across Canada.

In 1897 the city of Winnipeg began hiring a series of American experts to consult on their issue of an accessible and reliable water source (Perry 2016). The American experts were men who were socially valued scientific authorities based on their merit of institutional certification and the organizational recognition of their professional expertise. In 1906, Winnipeg and three nearby municipalities conglomerated, forming the Greater Winnipeg Water District (GWWD). The GWWD led the planning, organization and civil development of the much-needed water supply project. Shortly after, a proposal for diverting water from Shoal Lake to Winnipeg via an aqueduct became the solution of most significant interest.

Two Anishinaabe communities, Iskatewizaagegan 39 Independent First Nation and Shoal Lake 40 First Nation, were (and still are) located adjacent to Shoal Lake (Perry, 2016). The Anishinaabe of Shoal Lake lived on land rich in white fish, animals for hunting and trading and wild rice (Waisberg & Holzkamm, 1993). Waisberg and Holzkamm (1993) document that the Anishinaabe of Shoal Lake also had a long history of agriculture, planting gardens, and cultivating wild rice, with proportions of the resulting harvests sold to the market. The Anishinaabe communities had access to food and water from the land and were resourceful despite the increasingly challenging circumstances imposed on them at the turn of the nineteenth century (Perry, 2016). In 1881 the Canadian government prohibited the commercial sale of First Nations agricultural produce (Waisberg & Holzkamm, 1993), which prevented the Anishinaabe peoples from participating in the market economy. Another challenging circumstance was the opening of the Cecilia Jeffery Indian Residential School in 1901, which was in operation East of Shoal Lake 40 First Nation until 1929 (Perry, 2016). A chemist was hired by the GWWD for the water supply project and was stationed to live at the Residential School to continually monitor and test water samples from Shoal Lake.

By 1912, the construction of the 150km long Winnipeg Aqueduct from Shoal Lake had picked up significant attention from the authorities and people of Winnipeg (Perry, 2016). An American engineer, Mr. Slichter, hired by the GWWD, justified the construction and monetary cost of the Winnipeg Aqueduct. The project was estimated at 13.5 million Canadian dollars (CAD), which translates to 281 million CAD in 2015 values.

Preliminary surveying was conducted on the Shoal Lake 40 reserve by the GWWD without consulting the community (Perry, 2016). The mayor of Winnipeg approved the aqueduct, and construction began in 1914. The Chief of Shoal Lake 40 negotiated a contract with a member from GWWD to locally procure sand and gravel from the community for the project. The federal government Department of Indian Affairs intervened and prohibited the sale unless Shoal Lake 40 surrendered their rights. This is another early twentieth-century exemplary action of settler colonialism that forcibly prevented Indigenous communities from being independent economic agents in the market.

In the early 1900s, section 46 of the Indian Act legalized civil projects such as railways, roads, and public works to take reserve land without consultation or approval from the Indigenous communities (Perry, 2016). In 1914, the federal government sold approximately 3,000 acres of the Shoal Lake 40 reserve land to the GWWD because the designed aqueduct intake was on Shoal Lake 40 reserved land. Shortly after construction began, GWWD was concerned that humus-rich water draining into Shoal Lake from the Falcon River and Snake Lake would visually deter the eager taxpayers in their decades-long struggle to access reliable, safe water. There were two engineering solutions to separate this less desirable darker-coloured water. One was to extend the aqueduct 5 miles for 1 million CAD, and the second was to build a dyke to divert the flow for less than $1/6^{th}$ of the cost. GWWD chose the latter due to monetary

cost while knowing this decision would transform Shoal Lake 40 First Nation into an artificial island. The community burial grounds were used for the dyke construction (Failler, 2018). No consultation was conducted, and no approval was asked for from the Anishinaabe communities of Shoal Lake (Perry, 2016).

The resulting 150 km long cement aqueduct from Shoal Lake, bordering Manitoba and Ontario, was completed in 1919 and has been supplying water for the city of Winnipeg since (Perry, 2016). The people of Winnipeg and Canadians widely celebrated the feat; it was seen as a great example of western capitalism and engineering. Plaques, monuments, news articles, reports, and celebratory events over the decades proudly proclaimed the success of the Winnipeg Aqueduct, the engineering ingenuity to build it, and the resulting urban growth it supported. The public valued the aqueduct and its benefit to their city, but they did so unaware of or in ill regard to the dispossession of land and livelihood of the people of Shoal Lake 40 First Nation.

Now living on an artificial island, community members of Shoal Lake 40 First Nation used a small vehicle barge in the summer months and traveled by foot or light vehicles via ice roads during the winter months to access roads that would connect them with services outside of their community, such as groceries and water (Failler, 2018). Shoal Lake's Spring thaw and Fall freeze cycles were particularly dangerous for transportation, and several Shoal Lake 40 community members lost their lives from falling through the ice. Furthermore, unreliable transportation in and out of the community restricted emergency services and essential development services. Ironically, Shoal Lake 40 First Nation was then placed under a boil water advisory for over 20 years (Perry, 2016). Shoal Lake 40 First Nation advocated for a 27 km road, "Freedom Road", to be built, connecting their community to the Trans-Canada highway (Failler, 2018). Freedom Road would provide safe all-season access in and out of the community and a

means to develop local infrastructure such as a reliable water treatment plant. The Shoal Lake 40 First Nation community negotiated with the Federal government to construct a bridge or a road reconnecting their nation back to the mainland (Shoal Lake 40 First Nation, 2021b). When the Federal government did not approve this proposal, community members took it upon themselves to share their injustice with the larger population of Manitoba and Canada. One example of this occurred in 2007 when community members gathered and advocated for their rights at the proposed site of the Canadian Museum of Human Rights (Shoal Lake 40 First Nation, 2021b). There were also several protests, including barricades (Thompson, 2013) and walks (Bender, 2015) from SL40 FN to Winnipeg, designed to highlight the injustices hampering the community. Finally, with funding from both the Manitoba provincial government and the Canadian Federal government, Freedom Road was opened in Spring 2019. It was the first time in 100 years, and since the construction of the Winnipeg aqueduct, that Shoal Lake 40 First Nation had year-round, safe access to goods and services outside of their community. Refer to the Bernhardt (2019) and Perry (2016) citations for historical photographs, and maps, on the construction of the Winnipeg Aqueduct.

Problem Statement and Significance of the Study

In order for engineers and architects to work with Indigenous communities that do not perpetuate the harms of colonialism and capitalism, they must know how to support capacity building in the community, work in spaces of unbalanced power dynamics and allocation of resources, and contribute to culturally and environmentally appropriate and sustainable solutions. Furthermore, they must be able to recognize the limits of their professional practice and knowledge and be willing and open to modifying standard approaches in order to effectively collaborate with diverse professionals and worldviews as they engage in *wicked problems*.

Wicked problems are defined as problems and solutions that are "not clear and keep changing whenever we try to define them" (Gulikers & Oonk, 2019, p.1). Wals (2015) states that there is no single solution that is 100% reliable or generalizable to different contexts; the answer is ambiguous and entangled in the conflicting perspectives of multiple stakeholders. Mofox (2016) advises that due to their complex nature *wicked problems* cannot be solved; they can only be made better or worse. Sustainability-related challenges are also widely associated with *wicked problems* (Yearworth, 2016; Gulikers & Oonk, 2019).

Engineering Deans Canada, a pan-Canadian organization that promotes excellence in engineering education and research, has focused the engineering community on the "most compelling and critical issues facing Canada and Canadians today and for the next decade" with the six Canadian Engineering Grand Challenges for 2020-2030 (Engineering Deans Canada, 2021). The grand challenges are set within the UN Sustainable Development Goals and centre on *wicked* sustainability challenges, such as the following:

> Nearly two-thirds of the services provided by nature to humankind are found to be in decline worldwide. In effect, the benefits reaped from our engineering of the planet have been achieved by running down natural capital assets. We must learn to recognize the true value of nature – both in an economic sense and in the richness it provides to our lives in ways much more difficult to put numbers on. (Millennium Ecosystem Assessment, 2005, p. 5)

Two out of the six Canadian Engineering Grand Challenges require settler and newcomer conciliation with Indigenous peoples. The Engineering Grand Challenge #3, *Access to Safe Water in all Communities*, recognizes the unacceptable inequality and *wicked problem* of access to safe drinking water in Indigenous communities. Indigenous peoples in Manitoba make up

about 18% of the provincial population (Statistics Canada, 2017). In the Spring of 2021, there were 164,289 registered First Nations persons living in Manitoba, with 57.1% of the population living on a reserve (Government of Canada, 2021). Approximately half of First Nations peoples who live on a reserve do not have access to an all-weather road (Government of Canada, 2021). Furthermore, an estimated 5,500 homes are needed in Manitoba First Nation communities (Laychuk, 2019).

Challenge #6 of the Engineering Grand Challenges, *Access to Affordable and Inclusive STEM Education,* calls for a "more socially-relevant and outward-facing engineering curricula that emphasize multidisciplinary learning and societal impact" (p. 21). The Canadian Engineering Grand Challenges (2021) recognizes that:

> We [Engineering educators] need to build capacity in the profession of engineering for grappling with "wicked problems" and developing solutions that weigh diverse impacts – technical, environmental, social, cultural, economic, financial - and reflect a deep understanding and appreciation for global responsibility. (p. 2)

A significant part of capacity building to address "wicked problems" in engineering education is including diverse perspectives and participation from stakeholders who represent worldviews beyond the traditional engineering-centred perspective and practice (Yearworth, 2016).

Engineering and architecture graduates from the University of Manitoba are likely to interact with Indigenous peoples in their professional practice providing services for community infrastructure development. As well, education for sustainability is a growing priority in architecture education. In Altomone et al.'s (2014) study, 70.5% of about 400 participants working within or related to architecture professions in the United States of America strongly agreed that sustainable design should be included in the architectural curriculum. Some of the

many barriers for built environments with sustainable designs include lack of knowledge transfer between disciplines and prejudices from current economic and cultural norms. These barriers prevent thinking about sustainability-related ideas, actions, and possibilities. Altomone et al. (2014) advocate for architectural education to engage in broader subjects than those traditionally associated with sustainability and include structural engineering, construction, cultural studies, history and sociology, to provide a rich setting for design exploration. Riley et al. (2006) recognize that detached, independent, and specialized architecture and engineering curriculum is a barrier to advancing progress in sustainable building design and construction methods. They advocate that architecture and engineering designers need to be educated in an integrated process to work with builders in ways they can clearly see the relationship of their academic and future professional work with their social and environmental arenas (Riley et al., 2006).

Transdisciplinary approaches in education aim to bring different people and knowledge systems together that have been traditionally separated via disciplines and social, political and economic norms, in order to address *wicked problems* (Vermeulen & Witjes, 2021). Transdisciplinary pedagogy seeks to educate students on applying their disciplinary knowledge, skills and competencies collaboratively with ‘ever-evolving’ and ‘real-world’ knowledge from non-academic stakeholders (McGregor, 2007). The academic and non-academic stakeholders involved in transdisciplinary education are unified by a common challenge or project that allows each unique perspective and knowledge to be included in co-creating a novel outcome. For a positive novel outcome to occur, different sources of knowledge must be collectively validated and incorporated; such a process that disrupts hierarchies in knowledge (Greenhalgh-Spencer et al., 2017). Furthermore, transdisciplinary approaches require the participants to use rational and relational thinking and practices (Jahn et al., 2012). Therefore, transdisciplinary approaches

require a union of the technical and the social, a divide experienced by engineering students in their engineering programs (Faulkner, 2007). For architecture and engineering students, a transdisciplinary approach in working directly with a community stakeholder could help connect them to the specific context and demographic pertaining to their designs (Crysler, 1995).

Purpose of Study

The University of Manitoba Department of Biosystems Engineering and Centre for Engineering Professional Practice and Engineering Education is participating in research that critically examines how to include Indigenous peoples and their knowledge in engineering curricula (e.g., Carriere, Seniuk Cicek & Herrmann, 2023; Zacharias et al. 2022; Ruta et al., 2021; Seniuk Cicek et al. 2021a; Seniuk Cicek et al. 2021b; Dubiel et al., 2021; Forrest & Seniuk Cicek, 2020; Seniuk Cicek et al. 2020; Seniuk Cicek et al. 2019a; Seniuk Cicek et al., 2019b) as well as assessing the impact of such initiatives on engineering students' learning (e.g., Kilada et al. 2021; Mante et al. 2019; Seniuk Cicek et al. 2022; Thomsen et al. 2021; Wyllie-Runner, Seniuk Cicek, & Zacharias, 2023). By partnering with Indigenous peoples and learning from their diverse knowledge systems, engineers will be better equipped to effectively respond to sustainability issues that concern stewardship of the land and caretaking of people (Bowra, n.d.; Whyte et al., 2015; Seniuk Cicek et al., 2019b). However, little research has been conducted to assess the effectiveness of transdisciplinary approaches in engineering education to teach engineering students how to better work with Indigenous peoples, as proposed in Seniuk Cicek, Friesen, & Bailey, (2019b). Six research studies on similar courses or programs to the SL40 FN Design Build course are reviewed in Chapter 2. From these studies, only Riley et al. (2006) and Edmunds et al. (2013) have Indigenous community partnerships.

The SL40 FN Design Build course is a transdisciplinary approach to teaching and learning and is fundamentally different from standard engineering and architecture courses in that it strives for decolonization, community capacity building, diverse collaboration, holistic learning (mental, emotional, spiritual and physical), and real-world experiential learning. The course offered students a unique opportunity to learn at the boundaries of engineering and architecture practices, western and Indigenous worldviews and the theory and application of design work. Learning at the boundary is new to education research since learning has predominately been studied within boundaries of disciplinary practice (e.g., Akkerman & Bakker, 2011). Due to the challenges that occur at boundaries and the resulting ignorance of or consequences of negative conflict, education research is interested in learning at the boundaries that lead to continuity across socio-cultural differences (Akkerman & Bakker, 2011).

Boundaries are ambiguous in nature and represent an in-betweenness of worlds (Akkermann & Bakker, 2011). Ambiguity rules at the boundary but "has the potential to open new interpretations and practices" (Leung, 2020, p. 10). The in-betweenness represents both worlds or disciplines and, at the same time, neither world nor discipline (Akkerman & Bakker, 2011). Akkerman and Bakker (2011, p. 142) see that the "multivoicedness (both-and) and the unspecified quality (neither-nor)" nature of boundaries are grounded in the dialogue between people from each world who negotiate meaning. Thus, learning at the boundaries requires a relationship of some sort between the different people involved. The socio-cultural boundaries of this research will focus on the interaction and actions between engineering and architecture students and the interactions these students have with members of Shoal Lake 40 First Nation as the students collaborate to translate their design into a community structure.

This qualitative research case study is designed to detail and explore the impact on engineering and architectural students' learning in the transdisciplinary SL40 FN Design Build course. The interdisciplinary, intercultural, theory and practice boundaries the students navigate are explored via Engeström's cultural-historical activity theory (CHAT) activity systems. The students' learning journeys navigating these boundaries are presented as a narrative case in Chapter 4. The findings provide engineering and architecture instructors and faculty leadership with insight into how the SL40 FN Design Build course impacted students' learning and particularly as it relates to the goals of the faculties of engineering and architecture in contributing to conciliation with Indigenous peoples and to advancing sustainability practices. The research will also bring insight for engineering and architecture educators and faculty leaders on course improvements for future curricular initiatives that engage Indigenous knowledges, peoples and design principles to better prepare students for their professional practice in Manitoba and Canada. The findings from this study will be critically discussed in Chapter 5 to examine how continuity across socio-cultural differences is and is not established (Akkerman & Bakker, 2011).

Research Question

The following research question guides the thesis research: *How is student learning impacted by participation in a transdisciplinary design-build course offered by the Faculties of Engineering and Architecture at the University of Manitoba in partnership with Shoal Lake 40 First Nation?*

Theoretical Framework

The theoretical framework used to answer the research question is situated in a social constructivist paradigm and uses Cultural Historical Activity Theory (CHAT) activity system

analysis along with subjective interpretations. The students' learning is explored using multiple CHAT activity systems to map the relational components the theory holistically operates from.

Limitations

As an English speaker exploring relations with a different culture, I acknowledge that the words and language of this thesis are not neutral; they inherently favour the English world (Indigenous Canada, 2015; Little Bear, 2004). When the term *Indigenous* is used to identify people, ways of knowing and culture, it can be easy for people, largely unfamiliar with such, to not recognize the magnitude of diversity, detail and sophistication dwelling under the terms. Indigenous worldviews are complex and diverse across the numerous and distinct nations comprising Canada (Indigenous Canada, 2015). For example, over 50 different Indigenous languages exist in Canada (Indigenous Canada, 2015). As such, it is important that readers understand that when I use the term "Indigenous", my intention is not to pan-Indigenize Indigenous peoples, and the operation of the term "Indigenous" is another short-coming of the English language. Lastly, I acknowledge that, in the building of Canada as a nation, great success has been obtained for many people but great harm has been done to other cultural and gendered groups of peoples. This research contributes to a larger conversation on care for all peoples in Canadian society and the natural environment; conversation in which we hold and tend to both the pride and shame of colonial development in Canada as it exists today.

Furthermore, my background experiences and individual beliefs influence the research presented in this study. I am a woman of European descent, with a baccalaureate education in mining engineering, and with work experience in the extractive industry in Canada. I have had the great privilege of learning from and on the lands of Indigenous peoples in Treaty 6 and Treaty 8 territories. A framework I refer to often, and which is reflected in my thought process,

comes from Indigenous people. This framework explores the interrelatedness of relationship with self, others and the Land (Goodchild, 2021). I have also had the great privilege to travel and experience authentic and diverse livelihoods and natural environments in 6 contents (Oceania, Asia, Africa, South America, Europe, and North America). I have been deeply inspired by these global peoples' worldviews and ways of being, and the diversity and interconnectedness of nature, which help me to reflect more deeply on how I can shift aspects of my beliefs, mentalities and actions to live in greater harmony with myself, others and the Land. I also reflect on how an education at the baccalaureate level in Canada supports these types of shifts or not. I acknowledge the existence of diverse learning preferences and that a transdisciplinary approach to teaching and learning can benefit all individuals, but may be easier for certain individuals more than others. I believe that it is important to have diverse approaches to teaching in higher education to accommodate individuals' strengths and learning preferences and that there are pathways for students to learn how to work with different people. More information on my positionality and motivation for this research is provided in the *Validation* section of Chapter 3. As well methodological limitations are presented in Chapter 3. Chapter 6 discusses the overall limitations of the study.

Chapter 2: Literature Review

Chapter 2 reviews the literature on the history, theoretical understanding, practical motivation, and application of transdisciplinarity as seen in higher education. The thoughts and work from Jean Piaget, Erich Jantsch, and Basarab Nicolescu are explored. I briefly discuss the foundational nature of scientific knowledge and how transdisciplinarity allows for multiple different types of knowledge, with different foundations, to co-exist. The terms and practice of *disciplinary, multi-disciplinary* and *inter-disciplinary* are described to situate transdisciplinary as between, across, and beyond knowledge camps within and outside of academic settings. The literature review then considers how transdisciplinary approaches are used in higher education and for what purpose. Lastly, research on how transdisciplinary approaches have been used in engineering education are reviewed to better understand the associated teaching and learning environment and impact on students' learning.

Cultural Historical Activity Theory (CHAT) is explained in general and how it applies to this research. Literature on engineering and architecture students' identity and the culture of their associated programs are explored to help identify any encultured tensions from students' experience in the SL40 FN Design Build course. Furthermore, Indigenous' perspectives from Indigenous scholars in Manitoba are detailed to help discern how to respond to harm that may be present in the tensions.

A Historical and Philosophical Grounding of Transdisciplinarity

Transdisciplinarity grew through the discipline of science as a philosophical belief that it could help open dialogue between science and other realms of knowledge to expand and prevent the stagnation of knowledge contained in disciplinary silos. Transdisciplinarity is an approach to

"fundamentally address the relation between science and society" (Jahn et al., 2012, p. 9). Jahn et al., (2012) define transdisciplinarity as:

> an extension of interdisciplinary forms of the problem-specific integration of knowledge and methods; while integration refers to scientific questions at the interface of different disciplines in interdisciplinarity, in transdisciplinarity, on the other hand, it is about integration at the interface of these scientific questions and societal problems (p. 2).

The concept of transdisciplinarity, and the first published use of the term, traces back to Paris, France, in 1970, at an Organization for Economic Cooperation and Development (OECD) international workshop; *Interdisciplinarity – Teaching and Research Problems in Universities* (Nicolescu, 2010). At the workshop three scholars, Jean Piaget, Erich Jantsch, and André Lichnerowicz, provided their perspectives on the concept. Jean Piaget was a Swiss philosopher, researcher, and psychologist. Piaget's perspective on transdisciplinarity was focused on expanding scientific knowledge by questioning the foundation of which scientific knowledge was generated (Apostel, 1972). The Austrian scholar, Erich Jantsch, considered a more socio-technical interpretation of transdisciplinarity, specifically a higher education that would better harmonize the aim of science with society's needs (Apostel et al., 1972; Witt, 2011). Jantsch's approach to transdisciplinarity took root as an organizational principle for universities modifying the concept, principles, boundaries and interfaces of disciplines (Apostle, 1972) to address socio-technical problems created from knowledge fragmentation (Witt, 2011). André Licherowicz was a French mathematician and viewed transdisciplinarity as a way to describe a non-ontological characteristic of mathematics (Nicolescu, 2010). Licherowicz's views are not further discussed.

To Jantsch and Piaget, the significance of transdisciplinarity is that it considered underlying assumptions of knowledge formation, including the role of subject and object. In

Jantsch's view, transdisciplinarity provided a ground to discuss and conceive of a new "science/education/ innovative… system of man, society, nature, [and] technology" that would benefit the human species as they evolve (Apostel, 1972, p. 100). From Piaget's point of view, it was a movement for positivist disciplines to expand their thinking into relative realms; Piaget "elevate[d] the discourse from a world of empirical facts to a world of intelligible relationships and the focus of scientific activity to the study of structural interactions" (Apostel, 1972, p. 97). Thus, Piaget brought a subjective dimension to reality as it was commonly understood. Piaget and Jantsch had different motivations for the use of transdisciplinary approaches, but both started by questioning the nature of reality (ontology), the nature of knowledge (epistemology) (Cunliffe, 2011) and principles and values (axiology) it took shape from. In other words, "how our philosophical commitments influence the logic behind our research methods and our knowledge claims" (Cunliffe, 2011, p. 648). A key point underlying disciplinary and transdisciplinary differences is how objectivity and subjectivity relationally interact (Apostel, 1972).

Throughout the history of natural sciences, there have been phases where the fundamentals of reality were questioned and transformed (Heisenberg, 2019, p.20). When a threshold in intellectual development is reached based on its subjective foundation; "we arrive at the idea of limits of disciplinary knowledge" (Nicolescu, 2010, p. 19). Nicolescu (2010) states that disciplinary knowledge has reached a point of saturation and there are noticeable negative impacts experienced in the field of science and also broadly in society because of this. The development and separation of knowledges into disciplines may have reached a threshold point tipping towards "a disservice rather than a service" (Davies, 2009, line 22). To address the stagnation in the development of intelligence constrained by disciplines, and respond to the

threats to the survival of our species, we are led, once again, to consider the fundamentals of our reality, this time in modern science, and address, particularly, the subject/object divide. Werner Heisenberg suggests moving away from any ridged distinction of objects and subjects (Nicolescu, 2010) because the rational and binary approach to the subject-object divide has led to rigidity in our thinking (Heisenberg, 2019).

Rational thought follows a linear and binary logic where the observer is completely separated from the observed (Max-Neef, 2005). Here the assumption is that reality is concrete, reducible, and given, and that knowledge is acquired by observation and the measurement of physical quantities (things or systems) (Cunliffe, 2011). According to Heisenberg (2019, p.22), reality is "the totality of the connections that pervade and carry our life." Many different areas or layers of reality exist as "a web of diverse relations" (Heisenberg, 2019, pp. 22-23). This thesis and research only partially express what exists within select areas and layers of the many constituting reality. When human experiences and situations are put into words, the English language and subsequent classifications and categories can only partially communicate experiences (Tochon, 2010; Little Bear & Heavy Head, 2004). As people, we live with people from different cultures and backgrounds and other life forms that exist in a tremendously different world than ours. A different reality than our reality. The difference between worlds is "beyond our direct apprehension," limiting us to make indirect observations on the "different external conditions of their life" (Heisenberg, 2019, p. 22).

Basarab Nicolescu is a theoretical physicist in elementary particle physics at the French National Centre for Scientific Research in France and a professor of philosophy at Babes-Bolyai University in Romania (Nicolescu, 2010) and is a leading figure in the development of transdisciplinarity (Dincã, 2011). Nicolescu also follows Jantsch's lines and considers the role of

transdisciplinarity in the simultaneous development of science and humanity. In 1986 UNESCO and the Cini Foundation hosted a symposium, *Science and the Boundaries of Knowledge: The Prologue of our Cultural Past.* Seventeen participants worldwide, including Basarab Nicolescu, produced the Venice Declaration, which contains six points on the state of scientific knowledge and its service to society. The first statement of the Venice Declaration recognizes a change in the field of science brought on by developments in physics and biology, which challenge the field's epistemology, logical dominance and ultimate influence through technological applications used by everyday people (CIRET[1], 2012). While scientific development through the study of natural systems is expanding the current worldview, societal values are still based mainly on "mechanistic determination, positivism, and nihilism" and circle back to influence the field of science (CIRET, 2012). Mechanistic refers to a purely deterministic or physical explanation of a phenomenon (Oxford Dictionaries, 2021a). Positivism is a paradigm with the philosophical perspective that, "every rationally justifiable assertation can be scientifically verified or is capable of logical or mathematical proof, and therefore rejects metaphysics and theism" (Oxford Dictionaries, 2021b). Nihilism is a belief that life has no meaning and rejects any moral or religious principles (Oxford Dictionaries, 2021c). These terms fit within rationalism and are values existing in society where their limits are under question. The participants cautioned that not allowing for societal values to change and for science to advance into new territories of knowledge would be harmful to our survival (CIRET, 2012). In this sense the participants acknowledge that science is not value neutral. This first of the Venice Declaration statement aligns with Piaget, Jantsch, and Heisenberg's views to expand our understanding and

[1] In 1987 Nicolescu created the Centre International de Recherches et Études Transdisciplinaries (CIRET) (In English: International Center of Transdisciplinary Research and Studies), which grew into a worldwide organization involving 165 transdisciplinary researchers (Dincã, 2011, p. 119).

values of reality. The statement may sound radical and carry a strong sense of urgency for change but it opens a discussion to question how we have created the foundation of western higher education, and whose knowledge takes precedence. Transdisciplinarity is seen as an approach to prevent collective values and ageing societal structures from collapsing and causing significant destruction by updating values and transforming systems of practice. The seventeen participants determined in 1986 that, "scientific knowledge, on its own internal impetus, has reached the point where it can begin dialogue with other forms of knowledge" in a way that "recognizes the fundamental differences between sciences and tradition" that is complementary instead of contradictory (CIRET, 2010), therefore establishing continuity across difference. They see this as a "new and mutually enriching exchange between sciences and the different traditions of the world [which] opens a door to a new vision of humanity, and even to a new rationalism, which could lead to a new metaphysical perspective" on reality. This echoes' Heisenberg's (2019) and Max-Neef's (2005) views on the ability for transdisciplinarity approaches to contribute to the dialogue between science and other realms of knowledge. In this, we learn that transdisciplinarity is part of a 'deep education' where values, mindsets, and actions matter and are questioned for their ability to reach 'higher humane goals' (Tochon, 2010, p. 2).

Transdisciplinarity attempts to re-ground the relations between fields of knowledge so that multiple realities are widely validated and honoured on a higher plane of consciousness. It seems that transdisciplinarity is a movement toward pluralism of knowledge rather than the dominance by a single ideology. History reveals that religion and the divine right of kings once ruled, then rational thought took over to what could be considered as a modern-day monarchy, a repetition of history versus a transformation of practice. Our societal structures and beliefs are now revealing their limits to sustain; some elements are outdated and ready to be replaced, some

elements need to endure. Will an evolution in consciousness, as transdisciplinarity hints at, take place? A dynamic reorganization could unfold as relational and traditional knowledges re-emerge, build capacity, and adapt to the current climate, interacting and iterating to a point where multiple forms of knowledge co-exist, equipping us to survive another century. Or will the modern-day monarchy be replaced by a new singular version of elitism? From Piaget and Jantsch, we see that transdisciplinarity is an approach to research and education for the advancement of sciences and concerns the role and value of science for society (Apostel, 1972). We learn from Heisenberg that a constructed set of foundational assumptions influences reality. Nicolescu, similar to Piaget, advocates for science to once again question its foundations and fundamental nature, creating space and relational structures to connect separated and forgotten knowledges. Transdisciplinary approaches in science, for the sake of advancing scientific knowledge, exercise the idea of co-existing worlds and therefore might help contribute to a higher level of conciseness as in transforming education systems, ultimately preparing students with an orientation and skill set to simultaneously take care of themselves, humanity and the earth in this rapidly changing and unpredictable era. As such, this research will focus on transdisciplinarity regarding its socio-technical relational aspects in higher education for engineering and architecture students.

The Methodologies of Transdisciplinarity

Multidisciplinary, interdisciplinary and *transdisciplinarity* are terms and practices with distinguishing features based on the degree of epistemological openness (McGregor, 2017) and the complexity of the problems at hand (Balsiger, 2004). Disciplinary practices, as part of their foundation, have an epistemology, which are philosophical assumptions that dictate what counts as knowledge in the discipline. The degree of epistemological openness a discipline has refers to

how it accepts or rejects knowledge with differing philosophical assumptions. Disciplines are specializations in isolation (Max-Neef, 2005). Multidisciplinary is the enrichment of a disciplinary topic under exploration by considering perspectives from different disciplines (Nicolescu, 2010, p. 20). Here knowledge traverses disciplinary bounds but for the single goal of enhancing knowledge in only one discipline (Nicolescu, 2010. p. 20). Multidisciplinary work is thematically orientated and has no direct role in problem-solving (Balsiger, 2004). When a solution is desired, collaborative work is essential at initial motivation and leads to an interdisciplinary or transdisciplinary approach to knowledge production (Balsiger, 2004). Interdisciplinary approaches are most effective if the solution is purely scientific (Balsiger, 2004). Interdisciplinary refers to adopting disciplinary methods from different disciplines (Nicolescu, 2010. p. 20). Here new fields can emerge but still face pressure to confide in a disciplinary inquiry structure (Nicolescu, 2010. p. 20). Transdisciplinarity is the consideration of what is across (continuous), between (discontinuous), and beyond the foundational structuring of disciplines (Nicolescu, 2010. p. 20). Transdisciplinary approaches are utilized when "the striven solution is explicitly meant to consider experiences from affected persons" (Balsiger, 2004, p. 412). In this case, collaborative work transgresses disciplines because embodied or non-academic expertise is integral to problem definition and solving.

A disciplinary boundary is defined by "the totality of the results – past, present, and future – obtained by the laws, norms, rules and practices of a given discipline" (Nicolescu, 2014, p. 189). Multi and interdisciplinary boundaries are extensions of disciplinary boundaries and follow the exact definition (Nicolescu, 2014). The foundations of disciplines are constructed by groups of people based on social, political, economic, and ideological climates and are subject to change as these climates change (Davies, 2009). We are in a pivotal era with a significant amount of

change experienced on many fronts, as discussed in Chapter 1. This change is directing us, in western society, to look closely at our foundations, to question our understanding of reality, and to move forward with "new laws, norms, rules, and practices" necessary to explore the space between, across, and beyond disciplinary boundaries (Nicolescu, 2014, p. 189). Like disciplines in universities, religions and ideologies also have boundaries (Nicolescu, 2014). What do we learn if we approach understanding our present world simultaneously, relying on continuities and discontinuities of disciplinary knowledge and multiple inquiry foundations? Transdisciplinarity does not seek to be the next "super-disciplines, super-science, super-religion, or super-ideology" (Nicolescu, 2014, p. 190) as "there is no transdisciplinarity without disciplinarity" (Nicolescu, 2010. p. 20). There is no desire to abolish disciplines and disciplinary learning (Davies, 2009) or assume superiority. Transdisciplinarity is a transformative, theoretical, phenomenological and experimental approach (Nicolescu, 2014) to open mentalities to adapt to changing realities (Dincã, 2011).

Nicolescu (2010, p.22) developed and presented three axioms that underlie the methodology of transdisciplinarity, providing transdisciplinarity with a rigorous definition:

1. The ontological axiom: There are, in Nature and in our knowledge of Nature, different levels of Reality.
2. The logical axiom: The passage from one level of Reality to another is insured by the logic of the included middle.
3. The epistemological axiom: The structure of the totality of levels of Reality is a complex structure; every level is what it is because all the levels exist at the same time.

The first two axioms are derived from experimental evidence in quantum physics and according to Nicolescu (2010), "go well beyond exact sciences" (p. 22). The third axiom is generated from

quantum physics and other human sciences (Nicolescu, 2010). These axioms of transdisciplinarity align with "traditional thinking" or ancient knowledge from previous historical eras and Jean Piaget's sketch of transdisciplinarity (Nicolescu, 2010). Different degrees of transdisciplinarity will take form based on how much each of the three axioms are taken into account (Nicolescu, 2010). The axioms serve as a premise for further knowledge exploration. Transdisciplinary approaches are a tool to this exploration, and at the same time, the approaches themselves are still taking form (Max-Neef, 2005).

As mentioned in the previous section, there is more than a singular reality. Nicolescu's concept, Levels of Reality, describes this. Levels of Reality are present when "that which resists our experiences, representations, descriptions, images or even mathematical formulations" is experienced (Nicolescu, 2010, p. 22). Levels indicated and represent differing laws that define a structure "for example; quantum entities are subordinate to quantum laws, which depart radically from the laws of the macro-physical world" (Nicolescu, 2010, p.22). A difference in laws defining a reality and its associated space-time characteristics is a discontinuity (Nicolescu, 2010). The concept, Levels of Reality, "induce a multidimensional and meta referential structure of reality" that is non-hierarchical (Nicolescu, 2010, p. 23). There is no level of reality capable of understanding all other Levels of Reality, and a level of reality is what it is because of the co-existence of all other levels (Nicolescu, 2010). Each level is incomplete and is characterized as such (Nicolescu, 2010), thus representing limits or boundaries. Levels of Reality signify the "coexistence between complex plurality and open unity" because the laws governing different levels "are just a part of the totality of laws governing all levels" (Nicolescu, 2010, p. 23).

The logic of the included middle is what describes the concept, the Hidden Third, and represents the continuity, or zone of non-resistance, between Levels of Reality (Nicolescu,

2010). The zone of non-resistance is in the realm of the sacred or spiritual and cannot be explained rationally, with logic and reason alone (Nicolescu, 2010). Here we can begin to understand how transdisciplinarity is the co-existence of rational thought and spirituality, as "without spirituality, the knowledge is dead knowledge" (Nicolescu, 2010, p. 24). From an Indigenous perspective, knowledge is "imbued with spirit" and the spirit from that knowledge "is in relationship with other spirits" (Goodchild et al., 2021, p. 79). You will find in the case description presented in Chapter 4 that spirituality is an important aspect to infrastructure development of some Shoal Lake 40 First Nation members.

It is essential to distinguish what is a Level of Reality and what it is not. Levels of Reality are not the same as levels of organization (Nicolescu, 2010). Levels of an organization are not separated by discontinuities of fundamental concepts or laws like Levels of Reality are (Nicolescu, 2010). All levels of organization come from the same foundation. For example, university disciplines such as Marxist economics and classical physics are different levels of organization but belong to the same Level of Reality (Nicolescu, 2010), the same conceptual foundation. Within universities, though, there are disciplines at different levels of reality, such as Quantum physics and psychoanalysis (Nicolescu, 2010). Levels of Reality open up to the pluriverse.

Different Levels of Reality are unified or connected to other Levels of Reality by what Nicolescu (2010) terms as the Hidden Third. The Hidden Third is the zone of non-resistance, existing between the Levels of Reality (Nicolescu, 2010). A Hidden Third is a Transdisciplinary Object and a Transdisciplinary Subject (Nicolescu, 2010). The Transdisciplinary Object refers to the non-resistance between logical Levels of Reality (Nicolescu, 2010). The Transdisciplinary

Subject refers to the non-resistance between perceptions. Therefore, there are two dimensions to the zone of non-resistance and to move through it:

> A flow of consciousness that coherently cuts across different levels of perception [Transdisciplinary Subject] must correspond to the flow of information coherently cutting across different levels of Reality [Transdisciplinary Object]. (Nicolescu, 2010, p. 23).

The Transdisciplinary Object and Subject are unified by the Hidden Third which simultaneously allows preservation of differences and prevention of seeming contradiction (Max-Neef, 2005). This is explained as a ternary partition of subject, object and Hidden Third (Nicolescu, 2010). In rationalism, the object and subject are a binary partition (Nicolescu, 2010; Max-Neef, 2005) and do not open the zone of non-resistance. This does not mean rationalism is not essential but rather characterizes its limits. The Transdisciplinary Object and Subject do not become a hybrid product or a hierarchical order but rather aid rational and relational thinking (Max-Neef, 2005).

Everyone has differing perceptions of reality, and certain Levels of Reality are seen as more valuable than others. However, there is more going on behind the scenes because different Levels of Reality follow a self-organizing coherence that governs evolution; “a flow of information is transmitted in a coherent manner from one Level of Reality to another in our physical universe” (Nicolescu, 2010, p.27). In this manner, it is impossible to have a complete or closed theory; instead, the evolution of knowledge is ongoing and never-ending (Max-Neef, 2005; Tochon, 2010). To follow the evolution of knowledge requires one’s surrender of control, for ‘new’ knowledge is gained by being with the uncontrollable and ambiguous. The Hidden Third or zone of non-resistance is a tool helping us to traverse different Levels of Reality; it requires logical thinking and the accessing of information from within our core being (Nicolescu, 2010), which some may term as spiritual knowledge. It involves reasoning in both rational and

relational modes (Max-Neef, 2005), the “marriage between science and tradition” (Dinca, 2011, p. 126). This seems abstract, unattainable, and unnecessary from a purely rational perspective. However, a transdisciplinarity approach in traversing different Levels of Reality is thought by Nicolescu (2010) to be extremely helpful in navigating complex situations, and by Max-Neef (2005) to address non-linear processes in science. It is not that rational thought is no longer necessary; it has a place for addressing and creating certain things. A difficulty lies in believing that rational thought is the creator of all things without acknowledging and developing complementary creative forces. Transdisciplinarity thinking also has its role and place, particularly in transforming certain efforts in creating sustainable futures (Nicolescu, 2010) and in dialogue and actions that bridge science and spirituality (Max-Neef, 2005). Distinguishing between rational thought and transdisciplinary thought, respecting the limits of both, and learning to think in transdisciplinary ways, which are underdeveloped, is an important part of education and learning (Nicolescu, 2010).

> Our responsibility is to build sustainable futures in agreement with the overall movement of Reality (Nicolescu, 2010, p. 30).

Are we aware of our reality? Dr. Leroy Little Bear refers to the movement of Reality as underlying chaos or flux (Little Bear, 20201, December 2). Or are we, as peoples in the western society, primarily operating from one dimension of a multidimensional, ever-moving earth, energy, and cosmos, believing that this one dimension will bring order to our civilization? Does a transdisciplinary approach and way of logic assist us in understanding the movement of reality? Niels Bohr, a co-creator in the Rutherford-Bohr model of atomic physics that is commonly learned in chemistry, states:

> Day and night, particle and wave, sun and moon, male and female, reason and emotion, logic and intuition, matter and spirit, pragmatism and mysticism, discipline and transdiscipline; not as dichotomies, but as complements that converge and merge without losing their identities. (Translated in English, Max-Neef, 2005, p. 12).

Transdisciplinarity aims to contribute to the advancement of consciousness and has practical applications in economics, ethics, religion, nationalism, humanism, history, language, culture, and education (Dinca, 2011).

Motivations of Transdisciplinarity in Higher Education

The boundaries between science and society are becoming increasingly intertwined to the point where they cannot solely be treated as discrete categories (Danermark, 2003; Nowotny, 1999; Benessia et al., 2012). Furthermore, traditional beliefs of science being neutral or uninfluenced by politics and ideological orientations appear to not align with current challenges of environmental change and social development (Söderbaum, 2000). Science has become more sensitive to the context in which it operates and where members of society, non-academic partners, play an integrated role in addressing these challenges (Danermark, 2003; Tejedor et al., 2018). Reflecting such Vermeulen and Witjes (2021, p.31) state that transdisciplinarity approaches, as seen in higher education, are motivated by the following three conditions;

(a) pluralistic scientific and non-scientific knowledge creation at a high level of integration;

(b) to address the features of ‘messy’ societal problems;

(c) to deal with the urgency and persistence of (sustainability) challenges

Features of sustainability challenges include wickedness, complexity, and diversity of perspectives (Vermeulen & Witjes, 2021). Balsiger’s identified underlying motivations are

similar to Vermeulen and Witjes (2021). Balsiger (2004, pp. 412-413) identifies transdisciplinarity in practice when a "scientific problem transgresses the boundaries of scientific disciplines" under the following four conditions:

(a) the problem is generated in an extra-scientific field (economics, politics, the living world);

(b) a solution to the problem is urgently required in this field;

(c) the public opinion considers these fields relevant;

(d) when it is brought to science in an institutional way (research tasks, project financing).

Furthermore, (d) can be extended into institutional pedagogy as seen in courses, practicums and programs of study. The first conditions, regarding pluralistic knowledge, in both Vermeulen and Witjes (2021) and Balsiger (2004), align with the Venice Declaration of 1986, previously discussed, in that "scientific knowledge, on its own internal impetus, has reached the point where it can begin dialogue with other forms of knowledge", whereas "the fundamental differences between sciences and tradition" are complementary instead of in contradiction (CIRET, 2010).

McGregor (2007), similar to Vermeulen and Witjes (2021), states that transdisciplinary pedagogy supports the education of complex issues utilizing disciplinary knowledge, skills, and concepts connected beyond disciplinary bounds. Complex issues proposed to students include challenges that are not easy to define, 'ever-evolving' and are of the 'real-world' (McGregor, 2007, p. 5). The idea of connecting disciplinary knowledge with real-world knowledge acts as a bridge for the co-creation of knowledge from different sources (McGregor, 2007). Wolff (2017) reports that strict adherence to a disciplinary basis and the underpinning principles to a particular phenomenon, which define what knowledge is, are a barrier to developing students' code-

switching abilities or ability to make connections to other knowledge structures. Richter and Paretti (2009) conclude the same from their mixed methods research and further elaborate the importance of students to identify how their knowledge and how the knowledge of people different to them is key for solving a problem experienced by all stakeholders. Wolff (2017) advocates for engineering students to be trained in ways in order to respond to challenges in different contextual environments that bring to the forefront different knowledge structures. Additionally, instructors', students' and stakeholders' awareness and identification of each other's positionality related to the problem is crucial to a transdisciplinary teaching and learning environment. It may be that awareness and identification are learned not only via lectures but also in the collaborative process of problem defining and solving.

Guyotte et al. (2014) state that transdisciplinary approaches in education can lead to unexpected outcomes unachievable in a disciplinary setting. Unexpected results could be learning surprises or signals of discovery, in that a new frame of thinking was used to create something novel. Transdisciplinarity in practice contributes to situations where *wicked problems* impact the well-being and livelihood of people and the environment, as it is a way to contribute to novel solutions (Greenhalgh-Spencer et al., 2017). Transdisciplinarity approaches vary as they are context-specific and influenced by the academic and non-academic stakeholders involved (Vermeulen & Witjes, 2021; Nowotny, 1999).

Sustainability is a common genre of challenges and problems addressed with transdisciplinary approaches (Vermeulen & Witjes, 2021; Tejedor et al., 2018; Ahlström et al., 2020; Balsiger, 2014; Klein, 2008). Sustainability challenges are characterized by their complexity and are known as *wicked problems* (Rittel & Webber, 1973). Transdisciplinarity and sustainability align when sustainability inspirations and actions extend beyond existing

epistemologies and normative principles in modern science and societal structures and explicitly participate in pluralistic ways of being (Benessia et al., 2012). An example is in the co-production of knowledge between scientists and Indigenous communities, where evidence-based and other knowledge systems and western scientific knowledges systems are both valid in knowledge production (Benessia et al., 2012). This co-production process requires western scientists to continuously refigure their identity and negotiate the boundaries of their respective beliefs (Benessia et al., 2012).

Where transdisciplinarity occurs in academia

In higher education, transdisciplinary approaches can be found in research and pedagogy (McGregor, 2007; Vermeulen & Witjes, 2021). Since the introduction of transdisciplinarity in the 1970's, principles and practices of transdisciplinarity are emerging slowly in the social sciences, sustainability and health-related sciences, natural sciences, engineering, business, economics, multidisciplinary fields, peace and security studies, and arts (Vermeulen & Witjes, 2021, p. 27-28; Klein, 2008). Philosophy is the oldest example of a discipline with a transdisciplinary outlook because forms of knowledge are put in the light of epistemological reflection (Klein, 2008). Vermeulen & Witjes (2021) compares general fields within academia with the most significant use of transdisciplinarity approaches. Out of six subject areas presented, the greatest uptake of transdisciplinarity is within the social sciences, including psychology and the humanities at about 44%; engineering and natural sciences have the 4th most significant uptake around 20%. For the social sciences, scientific theories are expanding beyond the positivist way, which focuses on objectivity and neutrality; this is seen in the development of social constructivism, hermeneutics, action research, and narrative analysis (Söderbaum, 2000).

Pedological approaches that align with transdisciplinarity

The pedagogy of transdisciplinarity regards "the way of learning a curriculum" (Greenhalgh-Spencer et al. 2017). McGregor (2017) identifies nine different pedagogical approaches that foster transdisciplinarity learning: 1. integrative curriculum, 2. authentic curriculum, 3. value analysis, 4. transformative learning, 5. inquiry-based learning, 6. paradigm shifts, 7. learning communities, 8. double-loop learning, and 9. deep education. Greenhalgh-Spencer et al. (2017) include the term holistic learning. What is labelled as a transdisciplinary course may employ a curriculum that structures knowledge and learning in a non-hierarchical way. Where knowledge is acknowledged to exist in many different forms and is viewed as interconnected and interdepended (Greenhalgh-Spencer et al., 2017). Furthermore, the instructors of such a curriculum do not dictate a subordinate class of students. The students and the stakeholders are viewed to have an equally significant contribution to the knowledge generated in the teaching and learning environment. In other words, mutual learning is present, everyone engages in teaching, and everyone participates in learning (Klein, 2008). The curriculum centres around a problem where different knowledge sets are needed to define and solve it (Greenhalgh-Spencer et al., 2017). Students learn, through collaboration, when they have the opportunity to actively examine how their knowledge is positioned to that of other people's. Here it is essential to consider language and how different perceptions can be held in the same terms (Klein, 2008). Furthermore, Greenhalgh-Spencer et al. state that the exposure of collaboration and the diversity of exposure is essential for students to learn their positionality and how they relate to others.

Deep education involves deep learning, deep teaching and a deep sense of identity which "brings humanity to hard sciences" (Tochon, 2010, p. 4). Deep learning focuses on meaning,

finding links and gaps in knowledge across fields, relating theory to daily experience, and developing intrinsic motivation. Deep learning is contextual, situated, connected to the meaning of a task (Kember & Kwan, 2000), and supports the ideas and visions of development beyond the status quo (Tochon, 2010). A key feature of deep education is that students learning is transformative instead of transmissive. Transmissive education refers to surface learning and is information-focused, where students are required to memorize facts and develop reproductive skills (Tochon, 2010; Kember & Kwan, 2000). The students become extrinsically motivated (Tochon, 2010). In their research, Kember & Kwan found that content-centred approaches, summarized in Table 1, are more common when an instructor teaches via a transmissive means and that student-centred approaches are more common in transformative learning. Table 1 below provides characteristics of the content and student-centred teaching approaches. Student-centred approaches employed in a teaching and learning environment align with the principles of transdisciplinarity in education.

Table 1: *Content and student-centred approaches to teaching (Kember & Kwan, 2000)*

Content–Centred Approaches	Student-Centred Approaches
• Focus on content or material to be learned • Extensive amount of material is provided and covered • Instructor links content to their own experiences	• Focus on student learning • Learning is active and through discovery • Students relate to their experiences and build from them

• All students measured against external and pre-defined standards • Whole class instruction • Extrinsically motivated by grades • Exams and quizzes assess learning	• Diverse assessment methods to accommodate for different learning styles • Individual learning needs are accounted for • Intrinsically motivated

In summary, transdisciplinarity in the teaching and learning environment of university education:

- Recognizes that we as humans exist in an interconnected world; that our problems often arise at the intersecting fields of knowledges; that when knowledge fields are viewed as interdependent, a dimension to complex problem solving is unlocked;
- Transgresses boundaries between and beyond disciplines and academic walls;
- Uses an array of paradigms, methods and knowledges from diverse fields (academic and non-academic), which are determined by the actors involved; and
- The primary goal of solutions for complex challenges is that they positively contribute to a collective social well-being.

Transdisciplinary in Engineering Education

Research published on engineering transdisciplinary courses and programs was explored to understand what is happening in the teaching and learning environment and how student learning is assessed. This section reviews six different research papers on transdisciplinary engineering courses/programs similar to the SL40 FN Design Build course, introduced in Chapter 1. In five out of the six studies, engineering and architecture students and faculty are present and non-academic partners are actively engaged. The courses/programs are predominately problem-based learning rather than transmissive lecture styles and concern real-

world issues or challenges. The courses/programs in the research papers were explored for: description and objectives, problems proposed to students, role of the instructors, characteristics of the teaching environment, students perception of the learning experience, and student learning assessment methods.

Course/program description and objectives

Guyotte et al. (2014) created a Transdisciplinary Design Studio at the University of Georgia to educate eleven students from engineering, art education, and landscape architecture to critically and consciously navigate socially situated schemes and to develop the application of knowledge and skills that contribute to positive social and ecological justice. Students' had the opportunity to learn and practice public engagement.

Payne and Jesiek's (2018) study pertains to two different courses, an environmental engineering service-learning course with community-based design, and select sessions from the Engineering Projects in Community Service (EPICS) design program at Purdue University. Fifteen students participated in the three-credit, four-month-long, elective, interdisciplinary community-based design course with representation from "environmental and ecological engineering (12 students), political science (1 student), natural resources and environmental science (1 student), landscape architecture (1 student)" (pp. 6, 8). Seven students identified as female, and eight male. Twenty-five students from the EPICS program participated in the two EPICS skill sessions studied. The students were from various STEM disciplines and eight self-identified as female and eleven as male. The course and EPICS sessions' objective was to teach engineering students how to integrate non-technical dimensions into the community-based design, meet community needs and increase students' sustainability problem-solving competencies. Students from the semester-long, three-credit, elective design course engaged with

two local non-profit organizations, a community business, a funder from industry, and a local middle school throughout the course. The collaborative design approach with non-academic partners was novel to all the students involved.

Riley et al. (2006) created a series of courses called the American Indian Housing Initiative (AIHI). AIHI is housed in the Department of Architecture Engineering, at Pennsylvania State University, and is a year-long course series. The series began due to a recognized community need for culturally and environmentally appropriate and affordable housing on reserves in Eastern Montana and an academic need for practical sustainability education approaches. AIHI first took form as a two-week pilot project in 1999 and in 2002 grew into a new model for design and build education that focused on experiential learning where knowledge was co-created by the students, instructors and Northern Cheyenne partners. Members from the Northern Cheyenne Nation were lead collaborators, cultural teachers, and provided their expertise in the design and construction of projects. The objectives of AIHI were to develop sustainability-related competencies on; green building technologies, manage technological uncertainty, increase social/community and environmental awareness and responsibility, learn collaborative problem solving and design in diverse teams for engineering and architectures students. Between 2002 and 2007, 164 students completed the three-part course series, with over half of the students identifying as women. Riley et al. recognized AIHI as an interdisciplinary endeavour; however, the course series can be considered transdisciplinary as defined in this thesis.

The Berkeley Energy and Sustainable Technologies (BEST) lab, University of Berkeley, had a team of engineering, architecture and environmental faculty, undergraduate and graduate students involved in the Community Assessment of Renewable Energy and Sustainability

(CARES) research program. CARES had a research partnership with the Pinoleville Pomo Nation (PPN) on culturally appropriate, affordable and sustainable housing (Edmunds et al., 2013). In Edmunds et al. (2013), non-academic stakeholders include the PPN tribal government members, citizens, and employees. They worked closely with the students and instructors in the research, designing and building of community shelters. Undergraduate students who participated in CARES were first introduced to the research program with PPN in a first-year engineering design and analysis course.

Keenahan and McCrum (2020) studied an educational intervention at the University College Dublin for improving communication and teamwork between engineering and architectural students. The educational intervention was the implementation of a 12-week problem-based learning module which is equivalent to a three-credit semester-long course. The module focused on structural engineering and architecture building services. The module is a core course for first-year architecture students and an optional course for first-year engineering students. Approximately 120 students participated in the module each year, with an even split between disciplines. In 2018 103 students registered, with 59 from architecture, 44 from engineering; 58 students identified as male and 45 as female. In 2019 121 students registered, with 60 from architecture, 61 from engineering, with 73 who identified as male, and 48 as female. Although the study by Keenahan and McCrum does not concern a learning activity with a non-academic stakeholder, the study is relevant for assessing learning that happens in engineering and architecture student collaboration.

In Greenhalgh-Spencer et al. (2017), a year-long undergraduate Mechanical engineering design course, at Texas Tech University, was created to develop students' ability to apply their skills and knowledge to real-world problems in eco-rail transportation. A total of 38 students

participated in the yearlong design course, with approximately 75% identifying as a white male and 25% identifying as males of colour. Experts from specialties outside of mechanical engineering presented their perspectives to students regarding design considerations for an eco-railway. Experts were also available via an online messaging platform to address students' questions throughout the course.

The studies from Guyotte et al. (2014), Payne and Jesiek's (2018), Riley et al. (2006), Edmunds et al. (2013), and Greenhalgh-Spencer et al. (2017) are all from the United States of America (USA). The study by Keenahan and McCrum (2020) is from Europe. All studies consider a course/program with similar objectives to teach competencies, including non-technical skill development (collaboration, communication, awareness for environment and social needs) and technical skill development. All the courses/programs considered in the studies include engineering student participation. All studies, except for Greenhalgh-Spencer et al. consider courses/programs with both engineering and architecture student involvement. The most similar actor composition to the SL40 FN Design Build course is seen in Riley et al. and Edmunds et al. where engineering and architecture students collaborated with Indigenous community partners on the design and construction of buildings. Furthermore, all the courses/programs under study utilized transdisciplinary or interdisciplinary approaches in the teaching-learning environment. The course/programs had different durations ranging from a couple of sessions to a yearlong course. They also varied in ethnic and gender diversity, class size, and extent of non-academic collaboration with various community members. Keenahan and McCrum had the largest class size of approximately 110 students but did not collaborate with non-academic stakeholders. A large class size may be restrictive to non-academic stakeholder collaboration based on logistics.

The stakeholders in the courses/programs were the non-academic partners involved and included people from the general public, local schools, local organizations, Indigenous communities, and professional experts. Some stakeholders had more interaction with the students than others; for example, members from the Northern Cheyenne Nation and the PPN collaborated throughout the research, design, and building processes.

Problems or challenges proposed to students

In Guyotte et al. (2014) students were encouraged to "apply, stretch, and reconstruct" their approaches in addressing two different socio-technical design challenges of waste and water sustainability (p. 15). The first design challenge had students consider and visualize what landfill diversion would look like if zero waste goals were to be realized by 2030. Students conceptualized a community engagement initiative to facilitate broader public participation and visually inquired about the challenge through art-making. The second design challenge had students organize and implement a community initiative that used another piece of their artwork to engage with the public and discuss ethics on water stewardship.

Payne and Jesiek's (2018) community-based design challenge had students identify issues with stormwater management for an unhealthy local river, engage with local stakeholders, and then provide possible technical solutions.

In Riley et al. (2006), students were tasked with the design and build of a community strawbale walled building with the Northern Cheyenne Nation.

In Edmunds et al. (2013), students participated in culturally appropriate, affordable and sustainable housing design and collaborated with PPN. Furthermore, students' research involved exploring "engineering design models for community engagement" and interpreting

environmental and social data (p. 804). This data included potential wind energy, solar power, composting toilet performance, and water usage.

Student teams, composing of engineering and architecture students in Keenahan and McCrum's (2020) study were assigned four different interdisciplinary projects. The first project was to "convert a real-world example into a simplified Engineering system," which had the team sketch a free body diagram and label it (p. 8). The second activity was a group quiz where teams discussed the questions and decided on the correct answer. The quiz questions focused on structural engineering and architectural properties. The third project had students investigate and demonstrate how a structure's load, layout, and architecture (i.e. of a bridge or a tower) impacted the structural design. The final project had student teams design and model a scaled tower and demonstrate how gravity and lateral loads are accounted for in the structure's foundations.

In Greenhalgh-Spencer et al. (2017), students were organized into four groups: economic modelling, mechanical design, electrical systems design, and social issues. The social issues group researched information on environmental patterns and impacts and housing trajectories. The groups then had to work together and learn from each other to create a final design of an eco-railway that satisfied the needs of each group. Students incorporated learnings from non-academic experts in various fields.

The challenges that the students worked through in these studies were multi-faceted. Except for Keenahan and McCrum (2020), all the challenges had sustainability-related components (social, environmental, political, and technological). Student activities in all studies focused on designing solutions for real-world challenges that integrated multiple perspectives. These challenges required collaboration between students from different disciplines and non-academic partners. Greenhalgh-Spencer et al. (2017) had the least amount of interdisciplinary

interaction as all the students' were from engineering and role-played different perspectives. Greenhalgh-Spencer et al. did have professional experts from different fields engage with the students. Keenahan and McCrum (2020) had engineering and architecture students but no non-academic partners.

Role of instructors

Guyotte et al. (2014) imply that the instructors were mindful of the values and intentions behind engineering's production of technology and the building of many things and aspired to teach in ways that supported students to contribute to social and ecological justice. This was evident in the described motivation for creating the Transdisciplinary Design Studio, a collaborative effort between faculty from engineering, architecture and arts education. The instructors helped students make sense of a complicated sustainability problem by facilitating students to engage in thought, dialogue, and action. The instructors listened carefully to the student's dialogue and, when needed, encouraged students to see each other's points of view more deeply by asking them questions clarifying and challenging their base assumptions.

Payne and Jesiek's (2018) most significant contribution to students' learning was their underlying motivation for the course and EPICS sessions, which recognized the pervasiveness of socio-environmental issues as not neatly contained within a sole existing profession or practice. They questioned the limitations of dichotomously educating engineering students, separating the non-technical courses from the technical, and if the design curriculum develops students' "non-technical dimensions of collaborative problem solving" (p. 2). Both limits were viewed as barriers preventing engineering students from learning competencies needed to address sustainability challenges. Payne and Jesiek shifted their teaching focus to address these barriers to best prepare students for our future world. They provided their students with the opportunity

to learn through social engagement, situated learning, and transdisciplinary knowledge production.

In Riley et al. (2006) the instructor created the AIHI course series to educate engineering students so that they could see how their professional decisions connect to social and environmental contexts. The AIHI course focused on developing students' evaluative skills regarding the reliability and appropriateness of new technologies and intercultural collaborative skills, both which the instructor perceived as lacking in the engineering education.

The academics leading CARES role-modeled for students a co-design process and values of co-creation for sustainable housing that met PPN's needs of cultural and political sovereignty, environmental stewardship, and economic progress" (Edmunds et al., 2013).

The instructor in Keenahan and McCrum's (2020) study developed the engineering and architecture problem-based learning module due to a perceived need in the lack of education that focuses on interdisciplinary communication and teamwork. The instructor saw problem-based learning in teams as an effective way for students to learn communication and teamwork skills as it provided them with an opportunity to practice such. The instructor provided lecture-based teaching, facilitated group work, and provided feedback on the four projects.

In Greenhalgh-Spence et al. (2017), the instructor was motivated to try a transdisciplinary approach to see if it would help educate students design for real-world challenges. Furthermore, a student-centred approach was utilized. The instructor also facilitated peer-to-peer learning and organized guest experts to communicate with the class.

Kember & Kwan (2000) concluded from their mixed methods research that a university instructors' conceptualization of effective teaching strongly influences their approach to teaching. All the instructors in Guyotte et al. (2014), Payne and Jesiek's (2018), Riley et al.

(2006), Edmunds et al. (2013), Keenahan and McCrum (2020) and Greenhalgh-Spencer et al. (2017) utilized a student-centred approach in their teaching. This is seen in how they facilitated peer-to-peer learning, organized partnerships with stakeholders, were interested in deep learning and wanted students to learn by doing or through discovery. Also evident is that the instructors were motivated to change the traditional teaching and learning environment to provide education that, in their perception, better prepared students for their professional practice and relationships. The values present in the instructors include interdisciplinary and intercultural communication and teamwork, awareness and appreciation for people and place in technological design, sustainability, and the ability to contribute to wicked problems. The instructors efforts resemble grassroots initiatives as the courses/programs were created based on personal values and a desire to bring positive change to how students are prepared to serve the greater needs of society.

Characteristics of the teaching environment

In Guyotte et al. (2014) students were provided with an experiential learning opportunity to tackle complex, open-ended, and ill-defined real-world challenges. The student's public engagement initiative and artworks were put on public display in a gallery exhibit. This indicated that students' work extended beyond the classroom. Guyotte et al. report that the students partook in community engagement with the public but did not mention details on the location. The classroom layout was suitable for teams to break out into group discussions around separate tables. The curriculum in Guyotte et al. was inspired by Sparks of A Genius by Root-Bernstein (1999), and Are Your Lights On? by Gause & Weinberg (1990). The students were required to read both texts. Thirteen creative thinking tools such as synthesizing, recognizing patterns, observing, empathizing and play were explored in the curriculum through the first text. The second text fostered contemplation on the role of problem-finding, framing and solving in social

challenges. The students orally presented their community engagement initiatives and visual explorations (artworks) to their class and instructors.

Payne & Jesiek (2018) used problem-based learning and service-learning pedagogies, where students went to stakeholder sites and stakeholders came to engage with students on campus. For Payne and Jesiek students participated in lectures, readings, reflection assignments, group presentations, design charrettes, written group proposals, stakeholder feedback sessions, peer and self-evaluation.

In Riley et al. (2006) students from engineering and architecture gained hands-on research in strawbale wall technology. Students participate in a two-week build with intergenerational and intercultural members of the Northern Cheyenne tribe, instructors and alumni. The students lived and worked for two weeks in the Northern Cheyenne reservation, Montana, allowing them to learn from community members by sharing music, landscapes, and histories (Riley et al., 2007). Students engaged in research on campus for strawbale wall properties and took turns being team leaders (Riley et al., 2006). They used architectural plans, design renderings, and learned to translate them into an actual product. Students also experienced how to navigate uncertainty during the planning process on-site when issues of material availability and labour shortages arose.

The research conducted through CARES is considered participatory action research and had mutual benefits to all involved (Edmunds et al., 2013). Both academics from CARES and PPN decided what knowledge production process to use and how the concept of sustainability should be framed in the research program. Members of PPN travelled to Berkeley to meet with student designers to make design alterations; they also reviewed class projects. The students travelled to the reservation and hosted design workshops with the community. Engineering

students interpreted environmental and social data collected in PPN and collaborated with PPN citizens. This collaboration helped engineering students develop their social analysis and provided PPN citizens with expanding their technical understandings. Biomimicry was of interest to both parties as it touched on cultural principles valued by PPN and contributed to technological ideation in academia.

At the beginning of the course students, in Keenahan and McCrum's (2020) study participated in team-building activities to promote effective teamwork. Each team then drafted a policy statement setting student-generated expectations, guidance on working as a team, assignment of roles and responsibilities, and strategies for managing poor co-operation amongst members. Students worked in groups of 5-6 people. The teaching environment was designed inspired by Hartland et al.'s (2015) concept of *slow scholarship*. The projects spanned weeks instead of days to promote deep learning, and the course assessment was continuous across the four projects instead of standard examinations. Students in Keenahan and McCrum's study used computer modelling for the 2D design of medium density fiberboard elements and laser cutting equipment in the Civil Engineering laboratory to create tower models. Students were also provided with readings, submitted reflections, and gave oral presentations. Student teams submitted an assessment on each of their projects using rubrics created in class with the instructor. The instructor chose to generate assessment rubrics with the students to promote self-regulation of their learning.

In Greenhalgh-Spence et al. (2017) the diverse course content intended to promote deep learning and to help students make informed design choices for real-world transportation services. Students learned from experts in environmental sciences, social justice, and marketing via online conversations, podcasts and mini-lessons. They were also able to communicate with

the experts throughout the course via an online messaging platform. Students had multiple apprenticeship opportunities, engaged in project-based and peer-to-peer learning. Students' used a visual modelling software, Interpretive Structural Modelling (ISM), to visualize the interconnecting factors from each of the four different stakeholder groups.

Here we can see that the teaching and learning environment, in all the studies, are non-hierarchical. In Edmunds et al. (2013), the environment positively contributed to the cultural sovereignty of their academic partners. Students in Edmunds et al. and Riley et al. (2006) experienced life on a reservation, worked with culturally different groups. Except for Keenahan and McCrum (2020), a key feature is that learning happened both in and outside the classroom. Learning occurred outside of the school at sites of the non-academic stakeholders. Learning in the classroom was conducive to teamwork, i.e. tables and chairs that could be arranged for teams to work in small groups. Furthermore, community members were brought into the classroom for several of the studies. The learning environments fostered interaction and reciprocity between the students and involved the community stakeholders. Pedagogies of experimental learning, problem-based learning, service learning, participatory action research, and deep knowledge were utilized in the courses/programs.

Diverse content is present in the courses/programs and is dictated by the actors involved. For example, Guyotte et al. (2014) had engineering students use art mediums to visualize and conceptualize the challenge. Students utilized what they had previously learned in their disciplines, such as methods, practices, calculations, literature, computer programs to begin collaborating with students from other disciplines and external stakeholders. Students worked in diverse teams and engaged with stakeholders, which facilitated the collaboration process and provided opportunities to improve communication skills. Reading, lectures, team building

activities, contracts/agreements, reflections, oral presentations, peer and self-evaluations, and instructor feedback provided students with learning resources for effective communication and teamwork.

Student perception of the learning experience

Guyotte et al. (2014) provided student's quotes about their learning experience. These quotes reflected that design flaws became noticeable to the students when executing the design; the use of materials helped conceptualize connections between art, landscape architecture and environmental engineering points of view; empathy was important to understand someone else's needs; the public is more willing to participate in engagement activities based on their curiosity rather than by force; and that the class was a positive experience students wanted more of.

Payne & Jesiek (2018) provided student quotes from oral and written data revealing students' perception of their learnings. The students claimed they learned; that each stakeholder group and each student in a design group has something important to contribute; the project would not be successful without collaboration among everyone involved and integration of their expertise; diversity in expertise helped define a problem and find a solution; higher knowledge is gained when academic and non-academic perspectives are co-considered; the outcome produced was effective because different perspectives were integrated throughout the process; and transdisciplinary knowledge production can increase awareness on one's own biases and contribute to open-mindedness in problem-solving. Students commented on their learning experience being 'incredible', 'holistic', and overall highly impactful (pp. 18, 24).

Riley et al. (2006) provided quotes from students' written survey responses and revealed that students learned how to empathize without judgement with people from the Northern Cheyenne Nation; the interconnectedness of sustainability to all aspects of life; that they are

passionate and motivated about this type of work; the importance of listening; how to take feedback, how to ask questions, how to lead a team; and how different perspectives and backgrounds are a strength to problem-solving.

In Keenahan and McCrum (2020), student quotes about their experience working in interdisciplinary teams were gathered via surveys. Architecture students commented on learning patience, open-mindedness and adaptability when working with the engineering students. The architecture students also commented on how the engineering students held stereotypes about them, including the belief that architects just make things look pretty. The engineering students commented on learning how to adapt engineering principles to work with an aesthetic design, see a different perspective, and have other priorities but a similar end goal.

In Greenhalgh-Spencer et al. (2017), students' commented on learning to "learn new ways of doing things and new ways of seeing the world" (p. 86). Students also mentioned resistance and discomfort at the beginning of their experience. Still, after a while, they began to enjoy and appreciate learning from peers, doing creative work at their own pace, and being part of an open democratic process. The students also reported learning the importance of listening to and considering multiple perspectives of a problem and how engineering designs can exacerbate or mitigate social inequality.

Edmunds et al. (2013) did not provide student quotations regarding their learning experience. The students' perceived learnings in the other five studies reviewed in this section revealed three general categories: design, stakeholder collaboration, and teamwork. For design, students' learned the limits of their design perspectives; how design impacts the environment and people; that multiple perspectives and multiple uses of knowledge are essential for success; and how to be creative in different ways. For stakeholder collaboration, students' commented

learning that empathy and listening are necessary; their personal biases will be revealed in a way that encourages open-mindedness; and to see, appreciate, and trust a different perspective. Lastly, for teamwork, students voiced their learnings on how to take feedback; that each member has something important to contribute; and that working with people from other disciplines can break stereotypes.

Student learning assessment methods

In Guyotte et al. (2014), the instructors antidotally claimed that the collaborative process of thinking, designing, and creating across disciplines, and then engaging the broader public utilizing a transdisciplinary approach in STEAM education might help students meaningfully connect to the social complexities, environmental issues, and materials at hand, in order to contribute to positive change. The authors emphasized that student learning occurred when they were active participants in the course, learning by working with their hands and communicating with people of diverse backgrounds. Guyotte et al. noticed students developing creative problem-solving and empathizing with the intended audience during the design process. The art aspect of the course helped students make sense of the ill-defined issues by exploring different representations (i.e. visual instead of technical) through using multiple other tools and mediums. When interacting with the community members, Guyotte et al. commented on the importance of students being observant, reflective, and adaptable during the engagement process. Guyotte et al.'s article highlight what the Transdisciplinary Design Studio course instructors saw as the most significant elements of their teaching and learning environment.

For Payne and Jesiek (2018) a mixed-methods case study was conducted to advance the understanding of appropriate learning environments, teaching methods and student assessment in community-based design projects. Payne and Jesiek (2018) chose to use pre/post; interviews,

surveys, and written reflections, as the data sources. Inductive thematic analysis was conducted on qualitative data and statistical analysis for the quantitative data. Codes for thematic analysis were generated based on four design considerations: 'stakeholder considerations,' 'technical considerations,' 'non-technical constraints,' and 'broader considerations' (p. 10). This gave the authors a means to measure the "students' awareness of, understanding of, and ability to apply non-technical dimensions into community-based design projects" (p. 5). The authors also coded and analyzed data to explore the relationships between different actors involved in the transdisciplinary knowledge production. They did this by mapping out who was interacting with who, how often, and then described the characteristics of the interactions. The codes: 'collaborating,' 'defining the problem,' 'integrating,' 'mutual learning,' and 'emerging knowledge' were used to describe the different types of interactions taking place across the different actors (p.20).

Payne and Jesiek (2018) report that their mix-methods research results indicated an increase in students' awareness and understanding for "stakeholder considerations; the need to collaborate with stakeholders and integrate multiple knowledge types; and the importance of learning from stakeholders" (p. 28). The non-academic stakeholders the students engaged with during the project impacted the students' learning on integrating non-technical design elements more than that of their course instructors. However, they found that prolonged, consistent and direct contact with the non-academic stakeholders was necessary for students to learn in this way. Payne and Jesiek claim that a transdisciplinary approach in the knowledge production of community-based design projects, with significant and explicit community involvement, is an effective way to develop students' non-technical skills needed for sustainable design. Challenges

in guiding students to participate in a transdisciplinary approach in designs for sustainability were noticed.

Payne and Jesiek noticed that initially, engineering students had difficulty understanding the socio-technical problem presented due to their high familiarity with solely technical dimensions of problem framing and solving. Payne and Jesiek (2018) propose using problem scoping exercises at the beginning of the course and have students begin relationship-building with the stakeholders before the course starts so to better define, situate, and clarify the beyond technical problem space. A theory was not used in the data analysis of Payne and Jesiek's research.

Riley et al. (2006) report on several different methods to assess students learning in the AIHI course series. A 3rd party survey assessment, conducted in 2003, consisted of 13 multiple choice questions and one open-ended question. Twenty-six students participated in the survey. The survey found that the most apparent impact on students learning related to meaning, worldview, and identity, and was most strongly influenced by interacting with the community members:

- 48% of students identified working in the Northern Cheyenne community as their most meaningful experience in the course
- 54% of students experienced the most intellectual growth from working and researching in the Northern Cheyenne community
- 57% of students experienced development in global perspective when working in and researching with the Northern Cheyenne community
- 68% of students identified this work as contributing most to their understanding of other communities and other peoples

- 55% of students were greatly impacted by the course in terms of their choice of majors and professional goals
- 81% of students felt their experience in the course greatly encouraged or reinforced their participation in community or volunteer service

Research was also conducted by a graduate student for their master's thesis and considered student learning in "cultural awareness; understanding the concept of sustainability; teamwork and leadership skills; and multi-disciplinary interaction" (p. 154). Furthermore, Riley et al. (2007) conducted a qualitative case study to examine which of the learning elements in the AIHI course were most significant for developing sustainability and building competencies in students. The data was collected from four in-class discussions and three surveys and then coded for content analysis. The study revealed eight learning elements to be the most significant: "awareness and knowledge, skill development, application in diverse settings, reflection, responsibility, diverse interactions, partnerships, and lifelong learning" (p. 177). Riley et al. claim that these eight elements go best with a pedagogy that has active engagement, and the elements address ABET Criterion 3a-k, which are the engineering competencies required of undergraduate students for program accreditation. The authors conclude that the AIHI course series is an effective way for students to apply classroom knowledge, design and build useful products, observe their impact in a social context, and be motivated to think socially and environmentally about their decisions and find sustainable solutions (Riley et al. 2006). Riley et al. (2007) also report that students experienced an increased interest in sustainable technologies, "awareness of mainstream American culture and values," open-mindedness towards other cultures and their values, and understanding of the importance of communication and diversity in teamwork (p. 181). The studies of 2006 and 2007 publications do not use a theory in the analysis.

Three theoretical frames from the social sciences are used to analyze the co-design process that CARES and PPN members engaged in for how the partnership upholds PPN's cultural sovereignty (Edmunds et al., 2013). The first frame is that knowledge is situated, referencing Haraway's (1988) and Harding's (1995) definitions of situated learning. In situated learning, knowledge is generated with careful consideration of people's backgrounds and experiences, which influence their identities and how they see the world. Everyone's perspective is considered partial because of the infinitely different backgrounds and experiences, and therefore the integration of multiple perspectives contributes to a more robust problem framing and solving. Furthermore, some knowledge is more appropriate for specific needs than others. Students trained in western sciences began to see their cultural assumptions and how institutional actions and scientific practices have limits when considered from a Native American perspective. The second frame, articulation theory, is that distinct knowledge generated is connected to a cultural context and has strengths and limitations. Knowledge held within the PPN could be considered traditional and non-traditional. They gain information from multiple sources in their environment, such as environmental impact, self-sufficiency, and political experiences. The third frame relates to experiential knowledge, which validates Indigenous peoples "technical claims about the world" (p. 810). Indigenous Knowledges include more than important cultural understanding of "aesthetics, family structures, and ceremonial process"; it's also produced from "observations and analyses of economies, politics, machines, buildings, materials, global climate and other topics" (p. 810).

Edmunds et al. (2013) see that academic intuitions are more open to Indigenous Knowledges pertaining to the humanities but not when it comes to technology. Edmunds et al. reported the expertise of tribal technology was most strongly present in how PPN members saw

geothermal heating and the building of traditional in-situ homes, potential for wind energy generation (even though regional reports deemed it insufficient), identification of flooding hazards, and poor indoor air quality caused by housing design.

Keenahan and McCrum (2020) conducted action research to evaluate the problem-based learning intervention of enhancing teamwork between architecture and engineering students. They gathered and analysed qualitative and quantitative feedback via surveys from the 2018 and 2019 course offerings, midway through the course and at the end of the course. The surveys focused on participants' reactions to interdisciplinary teamwork and communication. Keenahan and McCrum grounded their research in a constructivist perspective and use dialogical theory in the analysis of the qualitative survey responses.

Keenahan and McCrum found that the educational intervention, overall, increased engineering and architecture students' knowledge, understanding and appreciation for each other's discipline. However, a small decrease in the understanding and appreciation by the engineering students, towards the architecture students, was noticed in the data at the end of the semester in comparison to the mid-semester survey responses. Students communication skills were found to have, overall, develop with a small decrease experienced by the architecture students from mid to end of semester. Overall the groupwork in the intervention was found to help develop the working relationships between the engineering and architecture students. Both disciplinary groups experienced a small decrease in developing interdisciplinary relations from mid to end semester. Keenahan and McCrum did mention that the technical content of the course increased in the second part of the semester and may be why the students experienced a decreases in understanding a different disciplinary knowledge, communication skills and interdisciplinary relationships building.

Keenahan and McCrum (2020) noticed that stereotypes between engineering and architecture were prevalent but the learning intervention was effective at challenging those stereotypes and ultimately fostered interdisciplinary teamwork and communication. The authors conclude that students' learning could result in increased empathy that architecture and engineering students have for each other. Overall the student's comments collected in the survey were very positive.

Greenhalgh-Spence et al. (2017) conducted a quasi-experimental study on a blind education intervention that used a transdisciplinary approach in teaching and learning design. For the intervention the instructor used a transdisciplinary design approach, similar to what he taught at the graduate level and used it for educating senior undergraduate engineering students. The instructor also taught the controlled section of the design course, without any intervention. Greenhalgh-Spence et al. (2017) developed a survey to gauge levels of engagement, levels of collaboration, and creativity experienced by students in both sections pre and post semester. Demographic information was also collected in the pre-surveys. The control course had 19 students' (74% white males, 26% males of colour) and the experimental section had 17 students' (70.5% white male, 29.5% males of colour). At the end of the second semester, interviews were conducted with willing students' in the experimental course section to collect information on their experience in the course and the types of skills they noticed development in. Data was also collected through classroom observations.

The data was analyzed with a cross-comparative method for the pre and post-surveys from both course sections (Greenhalgh-Spencer et al., 2017). Interview data was thematically analyzed using open coding to categorize the strongest emerging themes. Greenhalgh-Spencer et al. found that transdisciplinary approaches in the engineering design course increased

collaboration skills, trust, creativity, and problem-solving skills in students compared to students in the control group. Greenhalgh-Spencer et al. found that the increase in creativity, collaboration, trust, and engagement was most predominant in the students of colour in the experimental course. They found that this type of educational environment empowered underrepresented groups because multiple different types of knowledge and perspectives were valued, which helped create a safe space for diversity. Furthermore, the young middle-class white males in the course, the majority of students, found value in working with the minority students in the class and appreciated learning from their different perspectives.

Lastly, Greenhalgh-Spence et al. (2017) reported on situatedness as a central element to the course in that each students' background and experiences are situated in history and culture, thus influencing how they view the world and communicate bias. Greenhalgh-Spence et al. noticed that students relied on their bias to make sense of the activity, providing them with a sort of navigational bearing. Still, the authors also reported students experiencing moments of bias breaks. These are growth moments and happened when students realized that things are not what they thought or what happened was not what they were expecting. Bias breaks are moments where newness enters conscious thought and where a sense of openness or expansion is experienced. On a small scale, this leads to a change in how one views or judges certain people or ideas and, on a larger scale, a shift in one's world view or paradigm. Greenhalgh-Spence et al. state that this process of growing through bias breaks contributes to developing a sense of humility.

Themes and critiques on transdisciplinarity in engineering education

Aspects of situated learning are present in all the studies reviewed and happened through the orchestration of different disciplines and external stakeholders meeting face to face with each

other, where interaction and communication revealed unique backgrounds and beliefs. What students learned from these interactions is situational and self-awareness. They gained an understanding of where the other participants came from (Indigenous groups, community members, people from different disciplines) and the worldviews they held. However, from these diverse interactions, the students also learned self-awareness on their positionality in the group dynamic. Guyotte et al. (2014) exemplify self and situational awareness. Their Transdisciplinary Design Studio might help students situate themselves with their skills and knowledge to connect with social and environmental complexities. This relates to Riley et al.'s (2006) findings where the students observed their impact in a broader social context and evaluated environmental needs by interacting with the Northern Cheyenne people and effectively applied classroom knowledge to contribute to sustainable solutions. Keenahan and McCrum (2020) found an increase in students' understanding and appreciation for the other discipline, which might have come from an increase in awareness as Greenhalgh-Spence et al. (2017) discuss the importance of students being aware of their position for them to be able to appreciate a different perspective. Edmunds et al. (2013) also reported how knowledge and learning are situated and connected to cultures and histories and are actively acknowledged in the CARES program. Edmunds et al. drew on scholarly work from situated learning theory, articulation theory, and experiential learning theory when discussing how the CARES program was co-created and executed with the diverse students, faculty, and PPN community members. However, these theories rationally explain how different knowledge domains, i.e. western science and Indigenous, exist and how they are different. Still, they do not explain how to navigate different knowledge domains. In transdisciplinary learning environments, the different knowledge domains involved need to be acknowledged and understood, and as shown in the reviewed studies, this happens through the

development of students' self and situational awareness. The transdisciplinary or interdisciplinary approaches used in the research studies support an increase in students' awareness of the importance of understanding their positionality amongst knowledges different from their own when working on interfacing projects with people outside their discipline or academia. Inherent to the transdisciplinary approach in education, it brings people from different worldviews or paradigms together to learn about each other's world and their roles in interdisciplinary or intercultural relationships. This is a very different approach to teaching than the traditional lecture-based courses, which may be a limited way for teaching students self and situated awareness.

In all of the studies, the context where learning is taking place and is being applied is a relatively new space. The community of people learning and practicing together co-create the context from the ground up. This is seen in Guyotte et al. (2017) in how individual instructors from the different faculties decided to create and teach a course together for their students. Keenahan and McCrum (2020), Riley et al. (2006), Payne and Jesiek (2018), and Greenhalgh-Spencer et al. (2017) similarly created their courses/programs to fill perceived gaps in an education that prepares their students to respond to wicked real-world challenges effectively. This is where the transdisciplinary teaching and learning environment is slightly different from situated learning. The different communities of practice create a new community of practice through collaborative efforts. They are all learning how to share knowledge and work together instead of just one community of practice teaching people outside their domain how to participate in their activities. This is seen in Payne and Jesiek (2018), where the students reported that they learned collaboration is important for the success of the joint project. The students from Riely et al. (2007) also learned the importance of collaboration and that communication and

diversity are important. Keenahan and McCrum (2020) similarly found an increase in students' interdisciplinary communication skills and relationship-building from the collaborative work process. Therefore, in addition to situated learning, another process happening in the transdisciplinary environment to further navigate different worlds is the collaboration on joint projects.

It was reported in a couple of studies that students initially had difficulty beyond their disciplinary ways of thinking and practicing (for example, moving from a highly technical engineering focus to a technical and social focus). Greenhalgh-Spencer et al. (2017) had engineering students report their initial resistance and discomfort. Furthermore, the researchers noticed engineering students relied on their disciplinary knowledge first to make sense of the activity. Payne and Jesiek (2018) also reported that engineering students had difficulty shifting from a technical to a socio-technical approach in problem framing and solving. These two studies show that engineering students will approach problem solving relying on strategies and mindsets they were trained to master in their programs. When students are tasked to solve a problem with people of different backgrounds, using a transdisciplinary approach, the students have to learn how to shift mindsets, which in itself is something to learn and master and suggests that engineering students need the space and time to develop their awareness and collaboration skills.

The non-technical skill development of students largely emerged from interaction with students from different disciplines and with non-academic stakeholders. Skills include communication, listening, reflecting, observing, empathy, collaboration, recognizing and challenging biases, working through uncertainty, and understanding social and environmental impacts of design. Guyotte et al. (2014) and Riley et al. (2006) noticed students using empathy in

the collaborative process, and Keenahan and McCrum (2020) claim that the collaborative process could result in students' increased empathy. Guyotte et al. and Greenhalgh-Spencer et al. (2017) reported that students developed creativity and creative problem-solving skills through the collaborative process. Overall, students appreciated working in diverse groups and learning how incorporating different perspectives and ways of doing things helps solve complex or wicked challenges. The challenges posed to students and the interactions with people outside of their disciplines helped students contextualize and situate their learning in a real-world setting.

Critiques from the literature include logistical constraints and curriculum constraints in learning. Logistically the courses or programs tend to be smaller, less than 30 people, and depend on the extent of stakeholder engagement. Generally, higher stakeholder collaboration results in smaller class sizes. Due to stakeholder involvement, scheduling courses and projects can be a challenge when meeting the requirements of both academic and non-academic participants. Transportation costs are also a logistical consideration if stakeholders are outside of the city the University is in. Furthermore, all but one of the courses/programs was optional for engineering students and not part of the core program courses. It seems that the courses and programs are grassroots initiatives taken on by passionate and capable faculty and staff instead of an systemic curriculum intervention.

Edmunds et al. (2013) make an interesting observation that non-Indigenous people within academia tend to gravitate towards Indigenous knowledge relating to the humanities realm but not the technological realm. This might signify deeply ingrained beliefs that non-Indigenous academics have in that technology is what it is because of western science foundations. Therefore anything that is technological but outside of the rules and underlying assumptions of western science is not or rarely considered relevant by the western scientist or engineer.

However, according to Piaget, transdisciplinarity was to advance science by closely evaluating the underlying disciplinary foundations. He saw that discoveries could be made by adjusting the rules and underlying assumptions at the foundations of western science. Western science would still exist through transdisciplinary approaches, but a new space to discover would be opened up. The students in the studies indeed increased their awareness of their academic positionality. To see if this awareness extended to the foundations of their disciplines, we could look at the students' identity and see if it is reflected there. Riley et al. (2006) did mention that students' identity was influenced by interacting with the Northern Cheyenne community members, and Greenhalgh-Spencer et al. (2017) revealed a possibility that students experienced a shift in their paradigm, but both studies don't relate these identities and paradigm changes to the foundation of engineering practice. Students' transdisciplinary learning from the literature reviewed seemed to be strongest at the interface of different disciplines and cultures instead of and including a deeper opening and questioning of their disciplinary foundations and engineering identity.

Cultural Historical Activity Theory and the Contextualization of in the SL40 FN Design Build Research Study

This section explains the origin of Cultural Historical Activity Theory (CHAT) from Vygotsky's ideas, working in psychology, and then discusses how the theory has evolved into current day western institutions. Then, the activity systems of CHAT are described as they will be used to analyze the data for this research. Literature regarding Engineering and Architecture identity and culture is reviewed to understand the cultural-historical nature of Engineering and Architecture education. Lastly, literature written by Indigenous scholars with roots in Manitoba, including Margaret Kovach, Shawn Wilson, and Melanie Goodchild, is considered to gain insight into Indigenous perspectives of the western education system.

CHAT origins and description

Cultural Historical Activity Theory (CHAT) developed from Vygotsky's academic work on systems of human activity (Roth & Lee, 2007; Foot, 2014). Vygotsky based his activity theory within psychology to research human labour (Roth & Lee, 2007). Taken from Vygotsky's work on CHAT, Foot (2014, p.330) describes human activity theory as having three main ideas:

1. Humans act collectively, learn by doing, and communicate in and via their actions;
2. Humans make, employ, and adapt tools of all kinds to learn and communicate;
3. Community is central to the process of making and interpreting meaning – and thus to all forms of learning, communicating, and acting.

Since Vygotsky's activity theory, CHAT has evolved into a second, third, and fourth theoretical model (Engeström & Sannino, 2021) known as a *generation.* The second generation of CHAT was introduced by Vygotsky's pupil Leont'ev, in 1978, who added a temporal dimension (Roth & Lee, 2007) to define further the concept of activity as, "history is always present in human activity" (Engeström & Sannino, 2021, p.7). Leont'ev believed that instead of passive receivers or sole creators of knowledge, humans gained knowledge of the world by interacting with the world (Postholm, 2014). In other words, "neither the external world nor the human being in isolation is responsible for developing knowledge; rather they interact" (Postholm, 2014, p. 44). In activity theory, the activity, such as learning, mediates the external world and the inner or personal world (Postholm, 2014). Mediation relies on tools, material and or cognitive (Foot, 2014).

The terms in CHAT, cultural, historical, and activity, have meaning related to the theory's core ideas (Foot, 2014). Foot informs that the *cultural* aspect refers to the logic that humans are encultured, where cultural values and norms influence how people think and behave.

Furthermore, *historical* refers to temporality, where culture is grounded in history and evolves over time. Lastly, a*ctivity* relates to a group of actions situated in culture and time. Earlier histories of an activity (e.g. engineering education) can "persist in routine actions, in ways of thinking, in material artifacts and rules" (Engeström & Sannino, 2021, p.7).

The third generation of CHAT emerged around 1987, with Engeström's ideas on interactions between multiple activity systems. Near this time, sociocultural and cultural-historical frameworks on development and learning in social settings (Postholm, 2014) were spreading across continents. CHAT was introduced to western scholars by Michael Cole from the University of California (Roth & Lee, 2007). The fourth generation of CHAT is emerging from Engeström and Sannino's new work on activity theory that considers complex goals and objectives that transcend the temporal bounds of activities (Engeström & Sannino, 2021). Since the 3rd generation of CHAT focuses on multiple activity systems and the 4th generation of CHAT is novel and developing, this thesis research will primarily refer to the 2rd generation of CHAT, which focuses on a single activity system.

Activity systems are a central part of CHAT and provide a framework to map a "dyad of components" of a particular activity (e.g. learning in the transdisciplinary Shoal Lake 40 First Nation Design Build course) and "seek to identify how the other components are present and influencing the situation" (Foot, 2014, p. 332). The components are broadly categorized into *rules, actors, tools, focal entity, division of labour, and community of significant others* (Foot, 2014). They are visually organized into several triadic reactions in Engeström's, *Learning by expanding: An activity-theoretical approach to developmental research*, published in 1987 (Foot, 2014). Each of these six components have cultural and historical dimensions.

The upper triangle, *actor(s)*, *tools*, and *focal entity*, represents Vygotsky's (1978) fundamental contribution to CHAT (Postholm, 2014). CHAT emphasizes goal-directed actions leading to a focal entity that results in the desired outcome(s) of the actor(s) in the activity system (Postholm, 2014). The *actor(s)* in the activity system can be an individual or a group of individuals (Foot, 2014). These actor(s) can belong to different roles or positions representing multiple voices and differing perspectives regarding the focal entity of the activity system. The actor(s) use the *tools* as intermediary aids as means to contribute to their focal entity (Postholm, 2014; Foot, 2014). The tools can be material or conceptual and include protocols, language, computers, scientific methods and models, and cultural artifacts (Foot, 2014). These tools in CHAT are crafted based on the needs, values and norms of the culture and are adapted over time. Foot defines the *community of significant others* as people who share the same interest as the actor(s) and are involved with the shared focal entity. The relations between the community of significant others and the actor(s) are mediated by their tools and rules (Cole & Engeström, 1993). This community of significant others and the actor(s) make up the participants in the activity system. Cole and Engeström specify that the *rules* of the activity system regulate acceptable behaviour and interactions amongst the participants. Furthermore, the community of significant others implies the *division of labour*, is a "continuously negotiated distribution of tasks, power, and responsibilities among the participants of the activity system" (Cole & Engeström, 1993, p.7). The division of labour divides the participants' goal-directed actions (Postholm, 2014). The analytical strength of CHAT comes from the consideration of the whole unit, not just what may be the most direct relationships in the activity system, to deeper understand how all components are connected and interrelate (Foot, 2014). The objective of

activity system analysis is to reveal the more authentic motives behind the focal entity (Engeström & Sannino, 2021; Leont'ev, 1978).

Since Russian and German scholars developed CHAT, the translation to the English language can be restrictive for understanding the intent of the activity systems and the definitions of its terms (Foot, 2014). The concept of *activity* means more than simply a task or behaviour with definite points of beginning and end (Foot, 2014; Roth & Lee, 2007). The activity "involves people operating jointly in a persistent system of relations with other people and institutions as well as with the natural world" (Foot, 2014, p. 333). In this sense, *activity* should be thought of as holistic instead of a linear sequential discrete set of actions. The *focal entity* of the activity systems also has more of a holistic meaning which can be better understood by its three facets, the something-to-be-acted-upon, underlying motive(s), and the desired outcome(s) (Foot, 2014). The focal entity is formed by a need experienced by one or more actors. In the beginning, this need comes from the unconscious. The focal entity does not become apparent until the actor(s) acts upon things within the activity system and receive feedback information refining their need. It is here, in this back and forth process, where learning occurs (Roth & Lee, 2007). In the process of learning, the actor(s) will choose to act on certain things based on their personal experiences and their cultural-historical background (Foot, 2014). Once the need is in focus, the actor(s) have a transparent focal entity; the motive of the actor(s) is what guides their subsequent learning. The focal entity gives the activity systems identity and direction (Leont'ev, 1978). We can see here why there is a temporal component to CHAT because it helps track the reconstruction of the needs and motives of the actor(s). The evolutionary process of the activity system resembles a transformation concerning the outcome(s) (Roth & Lee, 2007).

Within an activity system, the participants engage in *activities*, do *actions*, and participate in *operations* (Foot, 2014). These activities, actions, and operations have interrelated roles in CHAT. In the previous paragraph, activities and actions were discussed. Actions are related to achieving goals (Leont'ev, 1978). Operations relate to the conditions of attaining goals (Leont'ev, 1978) and are often "routinized and unconcise components of actions" stemming from cultural-historical influences (Foot. 2014, p. 334).

Activity systems are complex, non-linear formations where tensions, disturbances, and innovations help drive transformation (Cole & Engestrom, 1993). Contradictions experienced within the activity system are present at four different "places" and allow for innovation to emerge (Foot, 2014). Contradictions are not seen as problems to fix, it's a sign of richness, mobility, and capacity for transformative learning and application of knowledge. Primary contradictions can exist within each component: rules, actor(s), tools, focal entity, division of labour and community of significant others. These primary contradictions can reflect fundamental tensions within a capitalist society where everyone and everything has inherent 'use value' and an 'exchangeable value'. Foot (2014) uses the economic terms 'use value' and 'exchange value' to denote where the tension is occurring. An example relevant to this case study would be that instructors (community of significant others) are educating (use-value) students and simultaneously receive a salary (exchange value) from students' tuition. Primary contradictions are a "coexistence of mutually exclusive elements" (Roth & Lee, 2007, p. 203) within a component of the activity system. When primary contradictions become conscious to the participants, they provide information to drive the development of the activity system. Contradictions at the primary level remain until transformed and can influence the nature of secondary, tertiary, and quaternary contradictions even though secondary, tertiary, and

quaternary levels of contradictions may not be interrelated (Foot, 2014). Secondary level contradictions occur when two components of the activity system come in contact (Foot, 2014). For example, the SL40 FN Design Build course instructors want to teach their students effectively but only have so much time. In this activity system, the instructors would be part of the community of significant others, and the academic timelines would be part of the rules. This secondary contradiction directly relates to the primary contradiction on 'use value' and 'exchange value' since timelines are grounded in economic resources. Tertiary levels of contradictions occur independently of the second level of contradictions (Foot, 2014) and emerge when there is a conflict between the focal entity of an activity system and that of "a culturally more advanced form of the activity" (Roth & Lee, 2007, p. 203). Tertiary contradictions between focal entities of activity systems can change the central activity system (Foot, 2014). An example of a tertiary contradiction is when a new participant becomes involved in the activity system and introduces a focal entity that challenges the existing focal entity and creates rifts between the participants in favour of change and those who are not (Foot, 2014). Quaternary contradictions occur between the central and adjacent activity systems and can be triggered by tertiary contradictions (Foot, 2014).

Researchers across diverse fields are using CHAT to advance curriculum development and teaching practices at all educational levels (Lockley, 2016; Wyatt & Nunn, 2019; Chao et al., 2017; Roth et al., 2013). For example, Lockley (2016) conducted a qualitative case study with an interpretive paradigm and CHAT as a theoretical framework to analyze the activity system of a professor's efforts embedding sustainability concepts and practices into their curriculum. Lockley focused the activity system on the teacher's perception of education for sustainability. CHAT was used as a framework to explore the thinking and values associated with the teachers'

decision-making and to identify the underlying focal entity motivating the teacher's activity. Data collected included interviews with the teachers, teacher focus group discussions and classroom observations. An activity theory framework mapped and analyzed the data based on the six activity system components. This study helped Lockley better understand the socio-cultural and historical influences on the teacher, particularly on their identity and how that influenced their curriculum development for sustainability and how they taught it.

Themes and critiques on the literature of CHAT

Every aspect of the activity system in Cultural Historical Activity Theory (CHAT), the components, contradictions, outcomes, and transformations are interconnected and connected in various ways to history and culture. Analysis of an activity system keep historical trajectories in mind (Foot, 2014). For example, research along the temporal formation of an activity system can identify preconditions for critical actions that shaped the present system and that may promote future development (Foot, 2014). CHAT is situated by culture, which is defined based on geographical positioning in the world. Culture is embodied in collective ways of life that take unique form influenced by nuanced characteristics in natural environments through natural resources, creation of art, tools, knowledge and the bonds between people and nature. CHAT enables researchers to engage in reflective and relational research through a multi-dimensional and systemic approach of understanding peoples motives based on a holistic view on cultural-historical activity systems composed of actor(s), tools, focal entity, division of labour, a community of significant others, and rules (Foot, 2014). CHAT acknowledges dualistic divides within components and between individuals and the collective, the material and mental, and the biographical and historical (Roth & Lee, 2007). The multi-voiced and multi-layered nature of activity systems allows for complex interactions between participants to be explored (Foot,

2014). Interactions are often complicated because the activity's actual motive can be complex for the participant to understand (Engestrom & Sannion, 2021).

A critique of CHAT is that it is relatively new to the field of western social sciences (Roth & Lee, 2007) with a holistic, temporal, and situated foci opposed to traditional point-in-time analysis of aggregated individuals (Foot, 2014).

Engineering identity and culture in post-secondary education

Culture is powerful because it is always present but difficult to identify (Okun, 2000). The next section of literature reviews engineering education culture and engineering student identity to better understand the standard norms, beliefs, and practices that influence engineering students' ways of thinking and doing. This will help identify the engineering related cultural markers in the activity system of this research.

Rationalism in engineering is dominant; it perpetuates the culture of engineering to strongly value the rational way. Engineering knowledge is built from the rational, empirical sciences and is used to analyze, review, design, test, evaluate, and determine requirements (Grimson & Murphy, 2015). Dringenberg et al. (2021) conducted a study with engineering students participating in capstone design projects near the end of their degree. Their findings support that rationalistic approaches are a cultural norm in engineering. Godfrey and Parker (2005) found that the engineering way of thinking focused on problem-solving and design and was dominated by reductionist methods, breaking down complex systems into separate parts. Dringenberg et al. (2021) suspect that the rationalist norm influences engineers and engineering students to believe that rationalism is the way, even in design, and that rational practice grants social acceptance. In this way, the social culture within engineering education places rationality at the top of a knowledge hierarchy. It leads to the marginalization of those belonging to non-

rationale though groups (Faulkner, 2007) and who value personal development in addition to technical skills (Stevens et al., 2005). The hierarchization of knowledge in the engineering culture is a barrier for diverse approaches to be taught and learned in design education (Dringenberg et al., 2021). This can result in culturally appropriate solutions being thought of as constraints to the engineering design rather than recognizing the existence of different epistemologies (Godfrey & Parker, 2010). Dringenberg et al. (2021) encourage teaching different engineering approaches (i.e. empathy and intuition) to be backed by changes in disciplinary social norms that support such changes. Otherwise, the engineering group's existing social pressures 'to belong' remain focused on and dictated by rational design. In reality, design requires multiple and different approaches.

Faulkner (2007) commonly finds that the biggest surprise to engineers when starting their first job is the lack of 'real' engineering work they do. From the perspective of engineering students, real engineering work is what they are familiar with from their education, primarily calculations and drawings. The transition from what engineers are taught to the types of environments and work done in the profession show gaps in students' social expertise needed in their careers. Social expertise such as professional development, communication skills, and social and environmental responsibility was present in the curriculum in Godfrey and Parker's (2010) study. Still, the material was marginalized to specific courses instead of present throughout the mainstream technical courses. Dringenberg et al. (2021) realized that empathy was considered a professional attribute but education on empathy was larging missing in the engineering degrees of their research. When non-technical skills were taught, they were often separated from the technical courses. There was a clear divide between the courses that taught non-technical skills, as they were referred to as soft, versus the hard technical courses (Godfrey

& Parker, 2010). Faulkner (2007, p. 332) states, “there is a deep technical/social dualism at the heart of engineers’ identities as engineers.” Godfrey and Parker (2010) noticed a potential and partial reason for the technical/social divide. Faculty sincerely believed it was their duty to ensure that the core technical content, mandated by international accreditation requirements, was entirely covered in their courses. It was observed that faculty had difficulty reducing or leaving out what was perceived as essential material. Furthermore, the essential technical content was mostly taught as lecture-based courses, a restrictive teaching method for developing social skills.

The technical/social divide can be further understood by exploring gender norms in engineering education. Masculinity is produced and reproduced through the socialization of the curriculum and its underlying attitudes, values and beliefs (Dringenberg et al., 2021). The technical engineering identity aligns with masculinities because of the hands-on nature of work done in the physical, visible, and tangible world (Faulkner, 2007). Godfrey and Parker (2010) found that one of the most deeply ingrained assumptions about an engineering way of thinking is that “engineering dealt with a tangible, definable, measurable, and qualifiable reality” (p. 10). Visual communication with symbols, diagrams, numbers, models, and graphics was the primary mode of communication for tasks that focused on a tangible reality. The masculinities of technical engineering made it easy for many men to identify as engineers because the hands-on nature of the tangible analysis is consistent with masculinities in society and which they are already comfortable with (Faulkner, 2007).

Furthermore, psychological research shows that the main difference between men and women is that women tend to be interested in people, and men tend to be interested in things (Su et al., 2009). Certainty men can be interested in people, and women can be interested in things, and this has to do with the amount of feminine and masculine qualities and preferences within

the individual (Kachel et al., 2016). The engineering culture, in many cases, encourages men and women to embody more masculine qualities than feminine. To identify as having social skills in engineering can cast people as being ‘soft’ and are culturally categorized as feminine qualities (Faulkner, 2007). Godfrey and Parker (2010) observed that female professors included in decision-making activities and offered promotions depended on “their ability to adapt to the prevailing culture rather than the prevailing culture adapting to absorb their differences” (p. 15). Professionally, a tension exists between the need for engineers to be experts in the application of math, sciences and technology (technical skill) but also for them to collaborate and communicate with people from different specialties and backgrounds (social skill) involved in the design process (Faulkner, 2007).

Faulkner (2007) encourages the engineering profession to embrace heterogenous engineering identities if they desire to grow in the effectiveness of their work. Technical roles and responsibilities are inextricable from social elements. Engineering roles are diverse, “in which the relative weight of technical and social elements (among other things) varies along a spectrum” (p. 351). With particular skills and interests, individuals will gravitate to roles that align with them. The binary cultural categorizing of social skills with the feminine identity and technical skills with male identity needs to be disrupted. Stevens et al. (2005) argue that to retain diverse students (anyone other than white heterosexual males), engineering education activities themselves must matter to students' personal and professional development. Okun (2000) identifies cultural norms of only one right way, valuing logic over emotion, competition over cooperation, binary thinking, power hoarding, and objectivity as not conducive to supporting diversity. If the engineering profession does not promote diverse identities and foster a culture conducive to doing so, it will miss out on attracting valuable talent (Faulkner, 2007). There is a

desire to change the engineering culture to attract new students and better equip engineering students for diverse workplace settings (Gonsalves et al., 2019) that appreciate knowledge and way of doing beyond the technical realms.

Godfrey and Parker (2010) found a persistent perception of engineering being workload intensive and that the work itself was challenging. They attribute this to the grading system and that the open-ended nature of the tasks students were being graded on could always have better solutions. Furthermore, the ridged program structure did not enable students to focus on their strengths as they could not avoid their areas of weakness. The teaching and learning paradigm of intense and challenging work pushed and pulled students to new limits. Godfrey and Parker attributed students' sense of pride and achievement to their ability to reach these prescribed limits. Faulkner (2007) also found that the male students felt powerful when they succeeded in the challenging program and had high academic achievement to prove their success. Tonso (2006a) reports that engineering students who embrace the rational way and its perceived sense of power and prestige gain a sense of belonging in the engineering profession. Stevens et al. (2005) recognize that an engineering education takes more than just learning disciplinary knowledge to become an engineer. The students must feel that they belong in the profession. The literature reveals a narrow window of personal characteristics and beliefs that students must be within, either naturally or forcibly, to feel a sense of belonging in engineering.

Tonso (2006b) found that engineering students worked better as a team and produced better work when the relationships amongst team members promoted egalitarianism and not the campus cultural norm of competitiveness. Godfrey and Parker (2010) noticed that faculty and students valued competition and cooperation but that the grading scheme promoted competition. The construct of time appeared to be viewed, by faculty and students, as a limited and inelastic

resource that needed to be carefully managed. When the complexity of a problem was high, and the problem definition stage could not be understood by objectivity measuring and quantifying concrete variables alone, a level of uncertainty became present. This uncertainty experienced by engineering students led to them making subjective choices and judgments throughout their problem-solving, but this was rarely acknowledged in the problem-solving process.

The knowledge that engineering is based on is temporal and should be updated as circumstances change and new evidence emerges (Grimson & Murphy, 2015). What remains critical is the usability of knowledge(s) for engineers to solve problems, address challenges, and innovate what has yet to exist. Knowledge was valued when it was relevant to real life (Godfrey & Parker, 2010). Therefore, engineering students need to connect their education to real life as they perceive it. A potential goal for engineering education is to develop individuals' strengths and passions and have them in roles and teams where their skills and talent are best utilized, respected and seen as an advantage in collaborative problem-solving. New engineering disciplines are emerging, and design and project-based curricula are increasing; both are examples of how engineering knowledge's assumptions are actively evolving (Godfrey & Parker, 2010).

Architecture identity and culture

Growing societal pressures of education for sustainability and diversity, equity, and inclusion of people and ideologies reveal tensions in traditional architecture education. This section will briefly explore the mainstream architecture culture, perspectives from researchers and professors on the emerging tensions, and how the tensions are being addressed.

Crysler (1995) recognizes a tension when architecture's cultural narrow norms of autonomy are met with increasingly diverse social demands for more appropriate buildings.

People are becoming more aware that the architectural profession and practice are compliant with “structures of power and dominant ideological agendas in society” and influence the detailed characteristics of architecture’s “autonomy of form and form-making” (Bozdogan, 1999, p. 207). This trickles into the architectural educational environment where transmissive forms of pedagogy are dominate and uphold the “ideological construction of autonomy, authority, and expertise” (Crysler, 1995). Marginalized populations, including women, and people of colour, have been increasingly vocal, advocating for the inclusion and development of their works (Bozdogan, 1999). A dichotomy exists in architecture education, for little regard is given to the historical understanding of architecture’s context, culture, and politics, leaving the design to privilege autonomous form-making and creativity. History of the built environment would reveal how a particular place is influenced by changing populations and demographics and how it takes shape and re-shapes over time.

Core educational material is often presented as transmissible via linear lectures that teach step-by-step processes and acquire student knowledge through recall and application (Altomone et al., 2014). A student’s competence is linked to the amount of knowledge they receive (Crysler, 1995). Under this form of pedagogy, students subordinate their racial, gender, class, and sexual identities to take on a prescribed education to become professionals. The model assumes that students are blank canvases ready to receive knowledge, regardless of their cultural and historical backgrounds. Kempenaar (2021) reports that landscape architecture education methods are traditionally rooted in developing individual creativity and ideas, which are very different from the emerging collaborative learning approaches across disciplines and with various community stakeholders.

Traditionally a dichotomy between creativity and technical rigour in design has existed, but now sustainable building design demands an increasing integration of creativity and technique (Altamonte et al., 2014). Altomone et al. (2014) claim a stark divide between design explorations that harness imagination, perceptual skills, and creativity and the technical material learned in core courses. A stronger relationship between lecture material and studio tasks is needed. Altomone et al. call for architectural education programmes to integrate technical practices with broad design skills for sustainable designs.

Various characteristics of the architecture teaching and learning environment are viewed as problematic. Architecture programs are rigidly structured, leaving little time and opportunity for students to choose alternative courses or educational experiences (Crysler, 1995). Time management is required throughout the degree for every task assigned has a due date; failure to meet the due date could result in a failing grade for the assignment. There is constantly a frantic pressure to get things done, complete assigned tasks and do it efficiently as possible. The perpetual conditioning of scarcity in time prevents deep learning and the development of natural talent. Bozdogan (1999) adds that far-spreading acclaim of architectural masters of the past and present celebrity designers, in part, shape the architectural community's culture. Demands of studio programs immerse students in their schoolwork resulting in them sacrificing interests outside of school and their well-being (Crysler, 1995). Architecture school is often described as a military boot camp where success is associated with reaching higher ladders on the hierarchy.

When students and faculty have never worked with people from other cultures, intercultural encounters and tensions are difficult for them to navigate (Hill, 2005). Reductionist approaches, stereotypes, prejudice, racism and ethnocentrism in teaching and educational institutions are barriers to intercultural learning and overcoming cultural tensions. The taken-for-

granted characteristics of one's culture become starkly evident through interaction with a different culture. To educate in and for a pluralistic society, students need to understand the culture of their community and navigate cultural boundaries. Hill (2005) encourages teachers to acquaint students with the power and validity of their voice which is connected to their background and experience in a community. A way to do so is through reflective learning, where values, identities, attitudes, and ideas of oneself and others are explored. Developing a student's autonomy and awareness differs from the professor or institution holding sovereignty and resembles more of a democratic process instead of hierarchical. Furthermore, students socialized in mainstream culture are likely not aware of their identity and biases because there was previously little need, within the microcosm, to question it. Hill advocates that student development needs to broaden its focus on employment skills by giving space for the development of the whole student.

We can turn to the work of Anderson (2014) and Gaber (2014) to see how they are moving through the tensions explored to create positive change in architecture education. Anderson (2014) is an Assistant Professor in Architecture at Iowa State University. Her values influence her views on architectural education on equity, empowerment, reciprocity and social justice, which are foundational to her architecture praxis. These foundational values influence how architectural design and work are carried out; Anderson (2014) reminds us to be mindful of these values throughout the entire process. Anderson (2014) recognizes that poverty, homelessness, and climate change are directly linked to the built environment and challenges architectural education to engage in and address these situations. Foundational values guiding the "how" it is done sets the tone, for the relational structures of the profession, to either providing a service to whom can afford or to engage in reciprocal partnerships with all stakeholders

regardless of socio-economic background. This relational shift evolves from a hierarchal form of relationships to equitable partnerships. How things are done, and the process, matter just as much as the final product and allow for engagement in social and environmental concerns. Anderson (2014) reports that students who engaged in these practices noticed that how they engage with people and carry out design is just as important to the community partners as the final product. Anderson (2014) talks about the practices that grow from foundational values of human decency and empowerment. The relationships that form generate an ecosystem where diverse individual knowledge is valued, shared, and utilized to transform a socially and spatially interconnected community.

Architecture schools in Canada have not been educating students how to design and build in Northern climates until Laurentian University's new architecture school opened to students in 2013 (Gaber, 2014). The curriculum includes First Nations and Francophone culture unique to the area of Laurentian University. Based on the committee's vision, the founding director of the new architecture school designed a curriculum that would integrate local cultures, natural resources, and industry potentials. The design-build method was used in all the studio courses. The scale and level of community involvement increased based on the student's year in the curriculum. The design-studio teaching and learning environment was designed to address issues in studio culture commonly experienced by students. The new curriculum for the design-build studios focuses on four central areas, "learning process, collaborative design, celebration of work and engagement of community" (Gaber, 2014, p. 25). Students are taught how to engage in collaborative design and receive guidance to develop these skills. The instructors also guided them in creative exploration and idea iteration. A student-centred approach instead of a content-centred approach to education is used. The design-build projects are situated within the city and

or communities and allow for clear links to learning culture and climate characteristics of the areas and populations. The design-build studio curriculum at Laurentian University supports students in developing their competencies about their local context and community needs.

Themes and critiques on the literature of engineering and architecture identity and culture

The themes and critiques of and for the literature reviewed regarding engineering and architecture identity and culture are provided considering both sections because of the similarities. Present in the literature is two main themes across architecture and engineering education. The first theme is the presence of dichotomies, and the second theme is ageing hierarchical and transmissive forms of pedagogy.

The presence of dichotomies in engineering education is highlighted in the tensions between social and technical knowledge, skills and competency and masculine and feminine qualities. Technical practices, skills, and knowledge are privileged at the top of a social hierarchy and marginalize other social related skills and competencies (Faulkner, 2007; Dringenberg et al., 2021). Furthermore, since the engineering way of thinking takes root in rationalism, the engineering culture has grown to accept rationalism as the primary way to address engineering design, problems, and teamwork (Grimson & Murphy, 2015; Dringenberg et al., 2021; Godfrey & Parker, 2005; Faulkner, 2007). Technical engineering ways of thinking and doing are primarily associated with masculine qualities of objectivity, reason/logic through visual communication via numeracy and modelling, and working with tangible and measurable realities (Godfrey & Parker, 2010; Faulkner, 2007). Since feminine ways of thinking and doing, centered in subjectivity, emotion, and nature (Keller, 1985), are already considered marginal to the rational technical, anybody with such competencies and the desire to develop such competencies

has a wavering sense of belonging and identity as an engineer. The social technical dichotomy becomes present when society and industry ask for increased diversity in gender and cultural backgrounds of engineers in order to represent diversifying populations (Faulkner, 2007). Boarder societal demands challenge the fundamental structure of engineering education and architecture education.

In architecture education, the current autonomy of form-making holds a privileged status that is narrowly defined in comparison to the growing need for designs for sustainability and social diversity and therefore limits the development of such (Crysler, 1995; Altomone et al., 2014; Bozdogan, 1999). Present in architecture education is separating technical core courses and the more creative arts-based courses or sustainability-related topics (Altome et al., 2014). Another division in architecture education is separating curriculum material from historical, cultural and community contexts (Crysler, 1995; Bozdogan, 1999). Divisions in technique, creativity, and contextual understanding are similar to divisions of rationalism and social practice in engineering. Both represent a lack of education on integrating two or more different knowledge sources in the curriculum and are particularly evident in the education for design.

Perhaps these divisions reveal an ageing hierarchical and transmissive educational structure where new growth ignites growing pains. The traditional architecture and engineering academic structure strongly embrace transmissive forms of teaching (Crylser, 1995; Godfrey & Parker, 2010). Students are taught to receive specific knowledge without questioning it and are granted the reward of belonging the more they recite what they were taught. Engineering and architecture students are socialized within their education by constant pressures of deadlines, dense and challenging course material, and high expectations to emulate experts (Crysler, 1995;

Hill, 2005; Godfrey & Parker, 2010). The education is demanding to the point where students are forced to sacrifice holistic development to become a professional (Hill, 2005).

Scholars and professors are becoming more critical of how teaching practices shape students' development and recognize an interplay with broader societal movements of sustainability, diversity, equity and inclusion. Such looks like teaching practices that foster transformative learning, design education that considers working with different disciplines and community stakeholders, development of students strengths where weaknesses are okay because of efficient use of teamwork, and students understating their role in society as it connects to their passions, experiences and backgrounds.

Dichotomies and change are excellent topics to be considered from a transdisciplinarity perspective and with the nuanced relational theory of CHAT. In this space of thinking and analysis, multiple different forms of knowledge, even contradicting views, exist and are beneficial, when meaningfully integrated and respected, for partially understanding a positive change in complex socially situated transitions.

Generalizations about the engineering and architectural education culture should be approached with caution as cultural changes are influenced by other factors in geographical space, institutional choices and broader social environments (Godfrey & Parker, 2010). What it means to be an engineer and what counts as engineering knowledge varies over time and locations and is, therefore, context-specific (Downey & Lucena, 2005). Engineering student identities are situated in social worlds, where how one views themselves is influenced by other people and institutional representations (Stevens et al., 2005). The literature reviewed did not regard the cultural landscape in engineering and architecture in Manitoba specifically, and

therefore is likely not to be completely representative of the cultural dynamic the SL40 FN Design Build course is situated in.

Although there is a compelling motivation for pedological practice to change, it is critical to acknowledge the dependence on and connections to the existing education structures of hegemonic discourses in which change seeks to disrupt (Crysler, 1995). Competing histories and political issues are integral to the critical transformation in education. Bozdogan (1999) also acknowledges that the dominant hierarchy of power, knowledge, and practice is becoming increasingly unequip for addressing the growing diversity of social needs but questions how to move forward without disrespect and disregard for the current structure.

Indigenous perspectives of education

Svalastog et al. (2021) exemplify how education has cultural and historical ties to society as education is "intertwined with the history of colonialism, racism, and sexism" (p. 1).
It is not only education in Canada that experiences these cultural-historical influences. The treatment of Indigenous peoples in Canada is similar to that in other countries and throughout the world's recent history. For example, the Norwegian Truth and Reconciliation Commission report the impacts and injustices of Norwegianization against the Sámi and Kven Indigenous peoples. The Truth and Reconciliation Commission of South Africa also reports complex injustices of colonialism and critiques attempts to amend political strife (Mamdani, 2002). Education systems designed and controlled by colonizers "never brought any good to Indigenous peoples" (Svalastog et al., 2021, p. 3).

Svalastog et al. (2021) critique the education systems at all levels, including higher education, in Canada, Norway and Sweden, for succeeding at its "hegemonic obligations in upholding White heteropatriarchy" (p. 3). One of the authors in Svalastog et al. (2021), who is

bicultural with Norwegian and Sámi heritage and a professor with expertise in Sámi health and living conditions, experiences strong resistance and feelings from members of the scientific community when she presents Indigenous knowledge in academia. The academic and public community regarded her research and advocacy on cultural appropriation, bullying, and determinants of health as emotionally-driven research on non-important issues.

Tensions between continuity and change in education "appear to follow the dynamics of social life in general" (Svalastog et al., 2021, p. 10). For example, the modern transmissive education system was designed to create a skilled workforce for industry. The knowledge transmitted targeted specific skill development and was measured by prescribed learning outcomes. This type of knowledge is removed from its context of time, place and people and is "forcibly shaped in ways that reinforce contemporary societal organizations" (p. 13). Knowledge without any broader context beyond its disciplinary categorization makes it difficult for people to learn information in ways with connections to their local conditions and culture.

Kovach (2021a) states that the colonial production of scholarship in Canada continues to be reproduced even after extensive efforts from the Truth and Reconciliation Commission of Canada, the Canadian Human Right Tribunal on First Nations child welfare, the National Inquiry into Missing and Murdered Indigenous Women and Girls, and the Indian Residential Schools Settlement Agreement, which resulted from the largest class-action suit in Canadian History. Canadian scholarship is based on colonial ideology, policy and culture (Kovach, 2021a). The same ideology, policy, and culture are responsible for the Indian Residential School system, a "bloodied gash that continues to wound and has yet to fully heal" (p. 337). This wound offers a possibility for healing if the collective effort of Canadians acts to minimize racism and

inequality. Kovach, echoing the voices of each author in the edited volume, calls for "Canadian scholarship to resist ongoing colonial reproduction in knowledge production" (p. 339).

Dalton & Wilson (2014) clarify for western scholars where they can get into trouble when aiming to decolonize scholarship and where their actions and literature perpetuate colonialism. The danger lies in positivist approaches and methodological debates to decolonize. Positivism relates to logic and rejects metaphysics and theism. To map western concepts communicated and understood with written English words to Indigenous worldviews is inherently a positivist approach. Doing so reduces Indigenous ways of being down to non-contextual bits so that these bits can be compared with western concepts. The act of reduction is an act of colonialism. Even research is reductionistic to varying degrees depending on how much of anything is abstracted and separated from the whole and "disembodies what is ultimately relationally embodied" (p.248). The process of abstracting and separating happens through enumeration, labelling, and categorization. Deloria Jr. and Wildcat (2001) critiques western thought and values to consist of dichotomies such as the object-subject divide and the nature versus human divide, limiting a more profound understanding of how the world works. Indigenous and western methodologies and concepts are fundamentally different and cannot be debated from the same grounds (Dalton & Wilson, 2014). Dalton and Wilson (2014) encourage western intellects and academics to question the foundations of their knowledge systems and the interplay of their cultural-historical lineage of colonialism and learn what it means to be outside of those confines.

Melanie Goodchild (2021), an Anishinaabe woman of the moose clan, recognizes that western epistemologies provide the foundations for systems-based approaches to tackling wicked problems. Goodchild's (2021) article models collaborative knowledge creation and sharing in an

embodied relational way instead of a rational way. In the Ojibwe (*Anishinaabemowin*) language, 'system' would not be a noun, as in English, but a verb imbued with spirit. The spirit of the system "is in relationship with other spirits" (p. 79).

Historically European and Indigenous peoples held differing worldviews that made it challenging to understand each other in compassionate ways, and to this day, the challenge prevails (Goodchild, 2021). It is not easy to respectfully incorporate multiple ways of knowing into a practice. Goodchild (2021) proposes a way forward where collaborative knowledge creation begins from a space in-between epistemologies. The in-between space is named *ethical space* by Cree legal Scholar Willie Ermine (Ermine, 2007). Ethical space affirms human diversity in a non-interference of one knowledge system taking over another (Ermine, 2007). Ethical space allows Indigenous placed-based knowledge to be privileged alongside western science and "honours Indigenous intellectual traditions emanating from spiritual wisdom" (Goodchild, 2021, p, 81). The nexus of Indigenous wisdom and western thought "are equal but differentiated" (Goodchild, 2021, p. 81). Therefore, does not come from the same basis and can exist simultaneously.

Principles from the two-row wampum belt are further used to set the stage for collaborative discussion within ethical space (Goodchild, 2021). Haudenosaunee people created the two-row wampum belt to visualize the 1613 Treaty between the Haudenosaunee Confederacy and the Dutch merchants arriving at the state of New York. The belt has two rows of purple beads, representing the Haudenosaunee canoe and the Dutch sailing ship. Above the first purple row, in-between the purple rows, and below the second purple row are three rows of white beads representing peace, respect, and friendship (Coleman, 2019). The purple rows also represent internal pluralism, distinct knowledge systems, and stay on a straight path without interfering

with the other boat or distinct knowledge system (Goodchild 2021; Coleman, 2019). The white beads also represent the "ever-flowing River of Life" (Coleman, 2019, p. 65) which both the Haudenosaunee and Dutch peoples can depend on for survival if they engage in peace, respect, and friendship with each other (Goodchild, 2021). Peaceful relationships are destroyed when one boat interferes and takes control of the other boat (Colman, 2019; Goodchild, 2021).

Goodchild (2021) presents a collaborative discussion between five people of Haudenosaunee, Tuscarora, American, and German-American descent. The topic of discussion is "How do we sense and then shift systems?" (Goodchild, 2021). Each participants contribution is written in English but with an unconventional structure (voices occupy their own column, simultaneously existing, but never crossing into another column, like the wampum belt) to encourage the reader to listen to the Indigenous voice, the western voice, and the voice in-between (Goodchild). An Indigenous way of understanding the world can be to look at the dynamic and interconnected relationships of oneself, relationships with others (i.e. western and Indigenous), and relationships with Mother Earth (Goodchild, 2021). Each participant recognizes how all three of these relationships have been damaged and provides insight and wisdom on healing (Goodchild, 2021). Both the western and Indigenous peoples attribute too far-gone paternalism, insatiable hunger for power and control, lack of sensory development to see, feel, and listen deeply, disconnection to nature, lack of understanding on who one is and where they come from, and disregard for sacred feminine principles and actions all as damaging to relationships. To heal is to address these violent acts and reconnect with ourselves, each other and Mother Earth.

Critical considerations for academia based on Indigenous perspectives of education

Indigenous people strive for co-existence with European settlers and new comers of Canada (Kovach, 2021a). Maybe this is seen as a threat to many in a system with no recent history of co-existence, just dominance. Indigenous peoples are asking for a fundamentally different way to live together, as the current system is recognized as detrimental to all of us (Kovach, 2021a). The river of life is in danger; it is our duty to work together across cultural differences to sustain and strengthen the river of life, the health of our planet, "so that all life will continue" (Goodchild, 2021, p.84). The shift begins with allowing for the full inclusion of Indigenous peoples in academia, where their voices are respected, heard, and integral to action (Kovach, 2021a) with increasing consciousness on western knowledge's origins and cultural-historical influences (Dalton & Wilson, 2014). The change will happen when people look inwards within themselves, with people's efforts in reconnecting to the land, and restoring the sacred feminine, which expands kindness, compassion, care, and love (Goodchild, 2021). Indigenous views on what will contribute to systemic change at fundamental levels include us deepening our consciousness and understanding of the world.

All the literature by Indigenous scholars is in English and not Indigenous languages and is written as opposed to oral, which is the traditional Indigenous way of archiving Indigenous thought. Therefore, the English written language restricts the level of understanding one can have. The Indigenous world is rich with information, knowledge, and wisdom and is only partially introduced through the English written word.

Summary of Chapter 2

Chapter 2 reviews and discusses the theoretical notions and applications of transdisciplinarity and cultural-historical activity theory (CHAT) in higher education and

engineering education research. Transdisciplinarity leads to a paradigm shift in what is considered knowledge and how knowledge exists, is formed and valued compared to disciplinary knowledge predominantly taught in engineering education. The shift in paradigm allows for student learning to be taught and viewed in different ways, which could help address complex social challenges such as reconciliation between western and Indigenous peoples. Transdisciplinarity considers knowledge between, across and beyond disciplinary bounds. Nicolescu's (2010) transdisciplinary concepts, Levels of Reality and Hidden Third, provide a logical explanation that that acknowledges the importance of spirituality in knowledge formation.

Transdisciplinary approaches in higher education require collaboration between and across disciplines and non-academic partners. They are often employed in design-, problem-, service-learning, and experiential-based courses or programs. The challenges that transdisciplinary approaches address are complex, ill-defined, and open-ended, and require diverse perspectives and knowledge. These challenges directly link to local issues and stakeholders and therefore situate students' learning in the real world of wicked problems. Transdisciplinary approaches in teaching and learning do not operate from a hierarchical structure. Instead, the structure is flat and facilitates a transformative student-centred teaching and learning environment. Students have the opportunity to learn technical and social knowledge and skills in an integrated way.

CHAT is a relational theory used to inquire about interconnected activities with historical and cultural traces and trajectories. Here the focus is on people: how they communicate, learn, make, interpret meaning, and interact with others, how this is done over time, and how this relates to cultural influences. The CHAT activity system is used to map the broad categories of

rules, actors, tools, focal entity, division of labour, and community of significant others and the relationships between them. CHAT activity system analysis will be used to view students' learning in the transdisciplinary SL40 FN Design Build course. Literature on engineering and architecture identity and culture is reviewed to better understand the historical and cultural dimensions of engineering and architecture education. Similarly, literature produced by local Indigenous scholars is reviewed to understand an Indigenous perspective on higher education. The literature on the history and culture of higher education critiques its rigid hierarchical structure, assimilative characteristics, and lack in the development of students' sense of self. This information will be drawn on in the analysis of the CHAT activity systems introduced in Chapter 3.

Chapter 3: Methodology

Chapter 3 details the interpretive and methodological frameworks of the research. The interpretive framework of the study is social constructivism. The methodological framework is a qualitative intrinsic case study. The case study research design is provided and introduces the research site, participants, and the research question. A section on ethical considerations for the research is presented, although ethical considerations are active throughout the entire research study. Then a data collection plan informs the data collection process. Following is a description of the data analysis method used for analyzing the data. Lastly, measures for upholding the trustworthiness and credibility of the data analysis and the overall methodology of the research are discussed.

Theoretical Framework

The theoretical framework in qualitative research depicts the philosophical assumptions orientating the researchers' perspective and guides the research process (Creswell & Poth, 2018). The interpretive framework influences how the researcher reports different perspectives and themes. For example, qualitative research considers multiple realities based on different views and perspectives of the research participants. The researcher attempts to lessen their distance to the participant in the study to understand better the participant's personalized perspective. As a qualitative researcher, I acknowledge that this research is value-laden and subjective and openly discuss the influences of such on the study. Ultimately the case study presented in the findings narrate a story of the students making sense of their learning experience in the transdisciplinary SL40 FN Design Build course. As I analyze the data and present the story I simultaneously make sense of my similar experience from being an undergraduate engineering student working with a First Nations community.

Social constructivism

The theoretical framework employed in this qualitative research is social constructivism. In social constructivism, individuals are believed to make personal meaning of their experiences in the world(s) they live and work in (Creswell & Poth, 2018). What is meaningful to the individuals are typically directed towards particular objects or things and are varied and multiple. Furthermore, these personalized meanings are also socially and historically formed through interactions with others and by historical, cultural norms present in the individuals' life and in the context of the situation being studied. As the researcher I focus on the complexity and interconnectedness of multiple views rather than reducing meanings and voices into categories and labels. In this way, the I am mindful of the participants positions in their social, cultural and historical context. I attempt to rely as much as possible on the participants' views and to interpret them accurately, however my backgrounds and experiences will shape my interpretations. Therefore, as a researcher, my positionality and story is provided in the Validation section as baseline information for the reader to use in differentiating my voice and the participant's voices.

Methodological Framework

A qualitative research method is adopted for the study. Qualitative research is holistic, not reduced to separate parts or elements (Stake, 1995). It is empirical based on field observations, is naturalistic, and avoids making grand constructs. While making observations I draw on my intuition, restrains from intervention, and am mindful of my interaction as a researcher with the participants. For example, when interacting with participants I am empathetic and listen closely to hear the participant's perspective. Like other research methods, qualitative research looks for patterns. The qualitative researcher relies on their understanding and interpretations of patterns in their observations and data analysis. They do so as consciously as possible to remain aware of their own biases and limitations in understanding other people or

interactions. The researcher uses their intellect, intuition, and emotion to interpret the meaning of the patterns. Qualitative research aims to understand complex webs of interconnections; the qualitative researcher inquires in such a way that they are consciously connected to the context of the study.

Research design: A case study

A qualitative case study research method (Creswell & Poth, 2018) is used to understand students learning in the transdisciplinary SL40 FN Design Build course. Case study research investigates a real-life, current, unique case to develop an in-depth understanding of a specific program, event, individual or community (Creswell & Poth, 2018; Stakes, 1995). Parameters that define a case include time, place, and the people involved (Creswell & Poth, 2018) therefore cases are a bounded system (Stake, 1995). One of the motivations for case study research is to gather accurate information about a case so that it is not lost by time (Creswell & Poth, 2018). Case study research does not aim to produce generalizable results (Stake, 1995). The goal is to understand the specific case, including the interrelationships between the people and things existing within it (Stake, 1995).

Cases are selected based on uniqueness of an event, (i.e., *intrinsic* cases), or a specific issue of concern, (*instrumental* cases) (Creswell & Pother, 2018; Stake, 1995). The research for this thesis will follow an intrinsic case study based on the following considerations. First, the research case regarding students learning in the transdisciplinary SL40 FN Design Build course was in existence and pre-selected to be studied before I started my master's program. This aligns with Stake's (1995) criteria for an intrinsic case study, in which a specific case is chosen based on its existing definable case bounds. The second criterion is that the transdisciplinary SL40 FN Design Build course is an unusual event and represents Creswell & Poth's (2018) and Stake's (1995) criteria of being a unique case. The transdisciplinary SL40 FN Design Build course, at the

University of Manitoba (UM), joins the faculties of Architecture and Engineering and is unique because of the multi-stakeholder collaboration employed in the design and build teaching and learning environment. At the University of Manitoba it is rare for engineering and architecture students to be taught together in the same course; at the time there was only one other course offered. It's also uncommon for North American engineering and architecture students to learn from an Indigenous community to the extent facilitated in the course. Another unique factor is the extent of practical hands-on work required to translate the design developed in the course to a real-world setting, designed and built with and for the community partners. The research by Edmunds et al. (2013) and Riley et al. (2006) were the only examples found in the reviewed literature to evaluate this unique type of transdisciplinary design and build course. A third consideration for choosing an intrinsic case study is that intrinsic cases embrace the narratives of the people involved in the case (Creswell & Poth, 2018). The intrinsic case study presented in this thesis research focuses on the student's learning experiences in the course.

The intended audience for this thesis research are professors and instructors from the Faculty of Engineering and the Faculty of Architecture at higher education institutions preparing students to design and work together with Indigenous peoples and knowledges. The intended audience is another motivation for using a case-study research methodology. Case studies are a familiar learning tool in engineering and architectural education and professional practice. The case study method will produce valuable information for future and similar course offerings. This case study is designed to be accessible and educational for engineering and architecture educators and professionals outside the SL40 FN Design Build course and furthermore, the University of Manitoba.

Research site and participants

As previously mentioned, the case for this case study research is students' learning in the SL40 FN Design Build course. This course was a complementary, 4-credit course for engineering and architecture students at the University of Manitoba. It was offered in 2019 in the two-month-long Summer term (May and June). Subsequent offerings in 2020, 2021 and 2022 have been postponed because of the Covid-19 pandemic. Although different a course offering for the Summer term of 2023 has been completed. This case study research focuses on the 2019 course offering. The course had teaching and learning activities at several different locations on and off-campus. On-campus, teaching and learning occurred in a design studio in the Architecture building, a prefabrication shop, and at the Indigenous Student Center named Migizii Agamik. Off-campus teaching and learning occurred at various locations within the Shoal Lake 40 First Nation community, including on the land where the shelter was built, on the lake shore about 10 km from the community centre; on the newly build Freedom Road; in the community, by a sacred fire, in the community hall, the Band office, and in the arena for a community powwow. The Shoal Lake 40 First Nation community straddles the Manitoba Ontario border and is about 150 Km East of the University of Manitoba.

The people involved in the 2019 SL40 FN Design Build course included 11 non-Indigenous students from the faculty of engineering and the faculty of architecture. There were several newcomers and students belonging to minority groups in the course. The majority of the students in the course and the student participants in this study belong to white majority groups. Since the population and sample size is small identity of the participants is protected. It is important to note that the six students from the course, participating in this research study, were the ones deeply affected by their learning experience. This lends to a population basis that does

not clearly evaluate the difference in perspectives between minority and majority groups and that values the transdisciplinary teaching and learning environment.

Three professors instructed the course. One professor from the Price Faculty of Engineering and one from the Faculty of Architecture were the official instructors listed on the syllabus. The engineering professor identifies as a professional engineer, male, who migrated to Canada 22 years ago from the Middle East. The architecture professor identifies as a practicing architect and a Métis man from the Kenora district in Ontario. A professor from the Center for Engineering Professional Practice and Engineering Education in the Price Faculty of Engineering was also an instructor in the course, although not officially listed due to university structural constraints (e.g., this course was an additional course in her teaching assignments). She facilitated and supported cultural learning opportunities in the course and identifies as a white settler and an educational researcher who would investigate the impact of the course on the course stakeholders. Two Indigenous Elders and knowledge holders employed with the University of Manitoba provided teachings and guidance to the students and instructors in the course. Elder Norman Meade, an Elder-in-Resident with the Price Faculty of Engineering and the UM Indigenous Student Centre presented to the students a Medicine Wheel teaching in the architecture studio. Elder Carl Stone, an Elder with the UM Indigenous Student Centre, taught the students how Migizii Agamik was designed and constructed with Indigenous worldviews. The course participants toured Migizii Agamik, the Indigenous Student Centre at the UM, and received another teaching on tobacco ties in the circle room. Several Shoal Lake 40 First Nation community members were directly involved with planning and facilitation of the course.

Other significant people in the course include, Roxanne Greene (now Balan) Community Councillor at the time of the course was the point of contact for the community; a community knowledge holder from SL40 FN who gifted the instructors and students tobacco to offer to the

land via tobacco ties, and opened the collaborative project in a good way with a drum song; the community women who ran the lodging and cooked for the students and instructor who lived in the community for the build week; a SL40 FN community member who owned a backhoe purchased with his Residential School Settlement funds, and cleared the land at the construction site, he also shared a story on how he was impacted from his time at the Indian Residential School, took up drinking because of the trauma, and eventually gave up drinking and became a powwow dancer; an Elder by the Sacred Fire on the day of the powwow, told the class a story of when he was taken as a five year old boy to Residential School and cried to see our partnership with his community, he also prayed and chose the land where the feasting shelter was built, he asked permission of and giving an offering to the family who relatives used to occupy the land; Aaron Balan and his construction crew, who built the feasting shelter with the students and instructors during the week-long build. Prefabrication professionals were also present to teach students during their time pre-fabricating the structure in the Sustainability In-Action Facility (SIAF) on campus. Lastly, a non-Indigenous female architecture graduate student was also involved with the course as a teaching assistant.

Research question

Research questions focus on the particular interest to be studied in the research (Creswell & Poth, 2018). Therefore, research questions set the direction of inquiry; they can also change or adapt during the research process to allow the researcher to "remain open to the nuances of increasing complexity" (Stake, 1995, p. 21). As the research progresses, unexpected themes may emerge, and the researcher may choose to use this information to refine their research questions. The research question guiding this study is: *How is student learning impacted by participation in a transdisciplinary design-build course in the Faculty of Engineering and Architecture at the University of Manitoba in partnership with Shoal Lake 40 First Nation?*

Ethical considerations

Ethical considerations are active throughout the qualitative research process (Creswell & Poth, 2018). This research considers and addresses all anticipated ethical issues of the proposed study since human participants are involved. The details are documented in an ethics protocol submitted to and approved by the University's Research Ethics Board (REB) (see Appendix A.1 for ethics protocol approval and Appendix A.2 for ethics protocol renewal). The Dean of Engineering and the Office of Institutional Analysis at the University of Manitoba have also approved this research. I have completed my Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans Course on Research Ethics (see Appendix B.1 for the certificate of completion).

Three principles that guide the ethical conduct of this research include respect for persons, concern for welfare, and justice (Creswell & Poth, 2018). Respect for persons pertains to every person involved with the SL40 FN Design Build course and, importantly the research participants. Throughout the research process, the people involved in the course had free choice to participate or not and were not coerced. All data received by the willing participants is securely stored, held in confidence, and anonymized to protect identity. The research does not intend to cause any harm to the participants and anyone involved in the course and is designed to give back to the participants in some capacity. The participants expressed in the interviews how grateful they were to participate by discussing, reflecting and sharing their experiences in the course.

Because of the negative conflict and tensions between western society and Indigenous peoples, this research has measures to prevent the perpetuation of harm done to any person. One of the course objectives was to have significant and explicit inclusion of Indigenous perspectives and knowledges focused on design. The non-Indigenous, domestic and international, students

learned about collective and local worldviews of Indigenous peoples from the Indigenous partners in the course. Therefore, students' learning was likely influenced by the Indigenous peoples involved. As this research, which is western-based, examines non-Indigenous students' learning who learned from Indigenous peoples, the research enters the space of Indigenous worldviews. To prevent any injustice to the Indigenous peoples involved, their worldviews, and their cultures, the Community Councillor from Shoal Lake 40 First Nation reviewed and approved the ethics protocol of this study before it was submitted to the REB. She added questions to the interview protocol to help her learn from the students' experiences. My research supervisor and I were grateful for this opportunity to ask her questions, on her behalf, to the research participants, as it helped us practice reciprocity, giving back to her and the community for all they did and have done to nurture and further our partnerships in the SL40 FN Design Build course and in this research. Furthermore, this relationship with the Community Councillor was maintained throughout the research to ensure research actions and decisions strengthen the relationship and do not contribute to miscommunication or overstepping of boundaries. One advisory committee member on this thesis is Métis, in which I sought their guidance to ensure culturally appropriate narration of students' learning in the course. The other three advisor committee members and I are aware of and educated on the colonial history of Canada and the harms of assimilation and marginalization of Indigenous peoples in society and academics. For example, I have taken two Native Studies courses and completed the Indigenous Canada Massive Open Online Course (see Appendix B.2 for a copy of my Indigenous Canada certificate). All four advisory committee members and I have personal and or professional relationships with Indigenous peoples, and three of my advisors were instructors in the SL40 FN Design Build course in this study.

One of the aims of this research is to contribute to reconciliation. Reconciliation is not an Indigenous issue. It is a societal issue and requires effort from the Canadian and British governments and the settlers and newcomers of Canada to establish and maintain relationships of respect, reciprocity, nation-to-nation sovereignty, and justice with Indigenous peoples. For a reconciliation between nations to occur, reconciliation from within ourselves also needs to happen. Reconciliation from within is a highly personal experience of reconciling one's inner and outer worlds and identities, finding a balance between giving and receiving, healing past trauma and current fears, and cultivating inner peace and security. The findings from this research may provide insight on learning that contributes to non-Indigenous students' reconciled relationships with themselves, with Indigenous peoples, between the architecture and engineering profession, and with the land.

Data collection

This section describes the data collection plan for the case study. The associated activities gather the information needed to answer the research questions (Creswell & Poth, 2018). These activities include ethical considerations, gaining access to the people of interest, purposeful sampling, data collection, recording of information, and securely storing data. Data collection for case studies considers a wide array of data sources to develop an in-depth understanding of the case. This usually results in the use of multiple different sources of data. Since this case study is designed to understand the students' learning in the SL40 FN Design Build course, data collection focuses on the students' learning experience. Furthermore, since the course happened in Spring 2019 before I started my master's program, and was not offered again because of the Covid pandemic, I make no direct observations. The data sources chosen for this case study are:

- Student online interviews (Engineering and Architecture students)
- Instructor online interviews (Engineering professor and Architecture professor)

- Student portfolios (Engineering and Architecture students)
- Course field notes (Recorded by observing Engineering Education professor in 2019)

Recruitment and consent

To begin participant recruitment, individual emails were sent (see Appendix C.1) to the eleven engineering and architecture students and the two instructors of the course, to notify them of the research and ask if they would be interested in participating. After two weeks, a recruitment email reminder (see Appendix C.2) was sent the students and instructors who did not respond. The students and instructors who agreed to participate in the research study signed and returned a Letter of Informed Consent (see Appendix D.1 & D.2). The consent form fully informed participants on the purpose of the study, what personal information would be asked for, and how their information will be protected. The recruitment email and Letter of Informed Consent asked the students if they would be interested in participating in this research through one or all of the following activities: an approximately 60 minute online interview, access to their course portfolio, and permission to use observation/field notes taken during the course in 2019. Students were offered a 25-dollar gift card for compensation for their time. The Letter of Informed Consent for the instructors asked for their participation in an approximately 60-minute online interview and/or granting permission for the researcher to use the observation/field notes taken during the course.

Participants were provided with the interview questions (see Appendix E.1 & E.2) before the interview and had the opportunity, after the interview, to review their interview transcript and make any necessary changes to reflect their views accurately. All personal information collected has been anonymized, password-protected, and securely stored. The communication between the researcher and participants did not involve any deception around the purpose and process of this study (Creswell & Poth, 2018). The participants were notified that they could withdraw from the

study at any time before data analysis. They also had the option to receive any resulting publications from the research.

For this case study, members of the Shoal Lake 40 First Nation involved in the course were not asked to participate in the data collection of this research for two reasons. During the Covid-19 pandemic, the community had limited technological resources accessible to them to participate in online interviews. This barrier was informed to me by the Community Councillor. Furthermore, the University of Manitoba mandated that research involving human participants must not be conducted in person due to the Covid-19 pandemic. The risk of meeting in person for conducting this research was too high for Shoal Lake 40 First Nation and the University of Manitoba. Second, traditionally academic research creates positions of authority where the researcher holds dominance over Indigenous peoples (Kovach, 2021b). The power-imbalance inherent in academic research requires significant effort to disrupt. Furthermore, translating cultural worldviews and differences contains a high risk for miscommunication. As a settler woman, I believe my position is to learn deeper understandings of life *from* Indigenous peoples and not to learn *about* them using the western approach of categorizing and labeling my observations and interpretations of what they say and do. It is more appropriate for me to research on and about my settler community at the interface of a cultural difference. Therefore, this research is grounded in my settler community but uses a critical view for how people like myself develop relations that lead to conciliation. Since this research is at the interface of cultural difference, the findings will be reviewed for cultural appropriateness before dissemination, and all the findings will be shared with the Shoal Lake 40 First Nation Community Councillor, and community members.

Interview protocol

An interview protocol has been created for the instructors and the students who consented to participate in the research. The participants signed a Pledge of Confidentiality (Appendix D.3), agreeing to hold confidence in what was discussed in the interview. I also signed a Pledge of Confidentiality for the researcher, agreeing to hold the identity and privacy of all the participants in the study in confidence (Appendix D.4). The interviews with the participants were securely conducted online and focused on one participant at a time. The participant chose the date and time of the interview.

Before the interview, an Assurance of Confidentiality (Appendix D.5) was shown and read to the participants restating the purpose of the research and the interview and reminding the participants of their rights. Participants' rights include the right to withdraw at any time during the interview and up until data analysis, permission to be video recorded for transcription purposes, and the protection and privacy of their personal information. As per protocol, the interviews were video and audio recorded for transcription purposes and these recordings were permanently deleted after the transcripts were member-checked by the participants. To protect participants' identity in the transcripts, pseudonym names were used, and any personal markers that could reveal their identity were anonymized or generalized. Participants were welcomed to ask any questions about the terms and conditions of the study before the interview and recording began.

The interview questions were different for the students and the instructors since the research is focused on students' learning in the course. The interview questions for the instructors are in Appendix E.1 and the interview questions for the students are in Appendix E.2. Both sets of questions comprise semi-structured open-ended questions (Creswell & Poth, 2018). The questions designed for the instructors encouraged them to share their detailed perspectives

on the students' learning in the course. The questions for the students encouraged them to share their detailed view on their learning experiences in the course. To grasp students learning as the course progressed, questions were asked about four specific phases in the course. The first phase began at the start of the course, the design studio, where the students were introduced to the design challenge and began working with each other on conceptual designs. The second phase was the two site visits to Shoal Lake 40 First Nation to meet community members, participate in ceremonies, and familiarize themselves with the construction site. The third phase was pre-fabrication at the Sustainability-in-Action Facility on campus, and the fourth phase was the build onsite at Shoal Lake 40 First Nation.

The interview questions were reviewed and approved by the Community Councillor. In a request to learn from students about their experience with SL40 FN and in order for both the students and community members to learn from this partnership experience and to apply their learning to future partnership relationships, the Community Councillor asked the researchers to add several questions. These included: *In coming to the Shoal Lake 40 First Nation (for the first time) were you prepared? What were your expectations? Were your expectations met? Exceeded? What could you do better the next time you visit our community? A First Nation? What could we do better the next time? What did you learn from the community? What did we learn from each other? What were the 3 best things that came out of this project for you?* We received ethics approval to add these questions to the interview protocol, and while conducting the interviews, we verbally informed participants that these questions were being asked on behalf of Roxanne Greene (now Balan), the Community Councillor (this is question #12 on the instructors' interview questions and question #6 on the students'). All participants were happy to respond to these questions. After the interviews, transcription and member-checking, the

participants' responses to the Community Councillor's questions were amalgamated and anonymized and sent to her for her information.

To mitigate the one-way dialogue that can be depicted by an interview script and the researcher's agenda (Creswell & Poth, 2018), the interviewers (myself and my supervisor) allowed for a less structured conversational inquiry to occur. My supervisor and I both engaged in this casual interview style throughout the interview, in addition to asking the scripted interview questions and using pre-formed prompts. In conversational inquiry, the interviewer influences how the interviewee responds based on what they say, and based on their tone and body language (Clandinin & Connelly, 2000).

Data Analysis

This section details the qualitative data analysis process used to describe the case of students' learning in the transdisciplinary SL40 FN Design Build course. Attentive to the students' experiences shared in the data collected, I orientated my thoughts and emotions to be as close as possible to theirs. However, I cannot *be* them; therefore, the meanings I drew are highly subjective (Stake, 1995) and dependent on my positionality. My positionality statement is provided in a subsequent section titled, *Positionality Statement as a researcher*, for the reader to grasp my background and experience, which shapes my subjective interpretation of the data. My subjective interpretations of students' learning are formed with the use of cultural-historical activity theory (CHAT). Since the focus of this research is to better understand students' learning in the transdisciplinary course the activity systems are centred on the students' perspectives and experiences. Below I provide a detailed description of how CHAT is operationalized, via activity systems, to answer the research question and trace the direction of students' collective learning in the course.

The first analysis phase was to read and re-read the dataset acquainting familiarity with the main story and actors at play (Braun & Clarke, 2006). This phase began immediately after conducting the first research participant interview. Stake (1995) states that as researchers immerse themselves deeply in the data, their intuitive understanding of the case increases. I immersed myself in the collected data and focused on the students' learning experiences in the course. The case study method utilizes multiple different sources in analyzing the case. Therefore, data analysis was conducted on the data collected which includes, students' perspectives via student interviews 2 years after the course, students final course portfolios which were completed at the end of the course in 2019, and interviews with the course instructors centred on their perspective of students learning. I wrote reflective memos to assist making sense of the students' experiences shared in the data. I also noted emerging patterns, potential codes, potential themes, and details of important instances. The following list is an outline of the first phase of data analysis:

- Write reflection notes after participant interviews
- Transcribe participant interviews
- Check transcription accuracy – listen to the audio file of the interview and checked the transcription document for accuracy
- Read and re-read through the data set (6 student interviews, 2 instructor interviews, 6 student portfolios and the field notes)
- Simultaneously write memos

The data set was very rich and contained 419 pages of textual data. I reduced the dataset to focus on learning moments rich in detail that occurred across most of the data sources. A learning moment is a specific concrete event that all participants experienced, and thus was present across the data. For example, on-campus Elders presented cultural teachings to students

is one ‘learning moment’. This process reduced the data set to 94 pages of single-spaced textual data. The following outlines the criteria applied to select data for further analysis:

- The data contributes to a learning moment
- The learning moment is present in the majority of the data sources
- The learning moment can be represented in a CHAT activity system
- Exception: If the data segment had a seemingly important weight to it and was only present in one data source, it was selected for further analysis
- Very little of the interviewers’ questions and responses were selected as part of the analysis

The selected data was attributed to its source with a marker (i.e. p. 27 X interview) in the event further contextual information or clarification was required during analysis.

Next, I organized the selected data into unique learning activities, in chronological order of the course, to be analyzed via the CHAT activity system framework. The unit of analysis is the activity system itself (Roth & Lee, 2004). I adapted Mwanza’s (2002) model: a list of contemplative questions to ensure that each learning activity consisted of data aligning with each of the 6 CHAT nodes. I modified the names of the activity system nodes, as represented in Mwanza’s 2002 model, to better represent students' learning activities in the SL40 FN Design Build course. The names of the CHAT activity system nodes and identifying questions used are presented in Table 2.

Table 2: Operationalization of the CHAT Activity System chart adapted from Mwanza (2002)

Activity System Node	**Identifying Questions**
Teaching and Learning Environment (TLE)	What is the environment of the learning activity? Who is involved? Where is the learning occurring?
Tools to Facilitate Learning (TFL)	By what means is the learning activity facilitated? What are the tools?

Students' Entry Point (SEP)	What are the students initial response to or experience with the tools to facilitate learning?
Rules (R)	What rules, norms, policies, standards direct students actions and responses to the learning activity?
Power Dynamics and Responsibilities (PDR)	What are the roles and responsibilities of the participants engaging in the learning activity? What is the power dynamic at play?
Focal Entity (FE)	Why is the learning activity happening? What are the students' focus? What is the aim of the students' learning? Can be conscious or unconscious.
Outcome (O)	What is the resulting desire and/or goal for participating in the learning activity?

Students' learning is described by analyzing and interpreting their learning pathways within a multitude of interconnected components and influences surrounding them in the learning activity. Each activity system has movement. The students' entry point (SEP) into the activity system is their initial response in encountering the tools to facilitate learning (TFL). The students negotiate the newly received information, using it as a tool to draw on personal experiences and knowledge, and to interact with the people and places in the teaching and learning environment (TLE). Students are also influenced consciously or unconsciously by the rules (R), which include norms and standards. Power dynamics and responsibilities (PDR) among the participants in the activity system dictate who does what and why. The negotiation and decision-making process of the students in the activity system reveals a focal entity (FE) and the direction of students' activity or goals, which is not necessarily something entirely obtainable. Ultimately, a result is realized as an outcome (O); that is, what the student learned.

I analyzed each learning activity using codes that were then arranged into the CHAT activity system framework. I codded the data inductively using a mix of in vivo, descriptive and value coding (Saldaña, 2009; Saldaña, 2011). I coded for words or phrases that I interpreted to

capture an essence, or be summative, salient or evocative of what was being communicated by the participants (Saldaña, 2009, p. 3). For descriptive coding these codes were primary nouns. The value codes highlighted the values, attitudes and beliefs of the participants. For the coding, I organized the data for learning activity in a column on the left-hand side of a Microsoft Word document. The right-hand side column was used to write the codes. A numerical superscript number was used to match the code to the data segment (Saldaña, 2011, p. 96). An alphabetical superscript was attributed to the code and the data segment to identify the node of the CHAT activity system that the code pertained to. In vivo codes were written in capitalized text and in quotation marks to acknowledge that the code is the participant's own word(s) taken directly from the data source (Saldaña, 2011, p. 99). Refer to Appendix F.1 for an example of coded data. The codes generated were then organized into a CHAT activity system (refer to Appendix F.2 as an example). Modifications or changes to the codes were made as they were applied to shape the activity system. A brief description of the activity was written describing students' learning journey through the specific activity. A narrative of the students' learning journey was written using codes and quotes from the data to provide a detailed description (Refer to Appendix F.3 as an example). Through a back-and-forth process of analyzing each activity system and reviewing memos, I reflected on what patterns and themes were emerging across and between the learning taking place in the multiple activity systems.

The data used for CHAT activity system analysis provides insight into students' background experiences, individual characteristics and personalities. These individualities are brought into the narrative findings presented in Chapter 4 in a way that protects the identity of the students. Identity protection was conducted by softening the boundaries between what each participant intimately shared in the interviews, portfolios and field notes. Importance is placed on what was said not who said it.

Validation

Specific triangulation procedures are used to validate the interpretations made and meanings inferred from the data analysis (Stake, 1995). Certain parts of the data, such as critical assertions or key interpretations, will yield contestability and require triangulation to confirm accuracy. The methods for triangulation in this study include peer-review, use of multiple different data sources, member checking of transcripts, providing participant quotes, and explicating researcher positionality (Stake, 1995; Creswell & Poth, 2018).

For the peer-review validation strategy, my supervisor who is familiar with the study, and who was present during the student and instructor interviews, reviewed my data analysis to ensure accurate interpretation of the data (Crewell & Poth, 2018). Furthermore, from a theoretical perspective, my advisory committee member experienced with CHAT, reviewed my analysis to ensure accuracy in how I applied the theory for this study.

The use of multiple different data sources allows for different perspectives or angles to be considered (Stake, 1995). If the same meaning and interpretation are found within the different data sources, the credibility is increased. This case study will use four different data sources that offer different perspectives on the students' learning, at two distinct temporal moments. The student interviews, conducted a year after the course, provide retrospective stories of their time in the course, and the student portfolios capture and showcase learning at the end of the course. Interviews with the instructors, also a year after the course reveal their retrospective perspective on students' learning. The field notes from an observing professor during the course provide an observational perspective of students' learning at the time of the course. Quotes from the textual data that are representative of the interpretations drawn are included in the findings of Chapter 4 (Detering & Waters, 2021). This is important for increasing the researchers credibility but also for including the participants voices in this research. The quotes are evidence from the data

supporting interpretations made (Stake, 1995). To assist in portraying an accurate meaning of the data to the reader I add clarifying words to participants quotes in square brackets.

The student and instructor interview transcripts have been member-checked by the corresponding participants to ensure accuracy of the transcription and expression of their thoughts. At the time of member-checking, participants made edits and changes to their interview transcript as needed. The interview transcripts used in data analysis are member-checked. The last measure of validation for data analysis is an explicit researcher positionality statement. As previously mentioned, qualitative research is subjective; my background and experiences influence my interpretations made. By explicating my background and experience related to this research, I can better decern my biases as they arise during data analysis and provide the reader with baseline information constituting my interpretations.

Positionality statement as a researcher

A predominant theme in my life is learning to navigate different worlds. My parents separated when I was a young child and for 14 years I went back and forth between very different households. I learned to adapt to the different rules and how to engage in different relationships. My mother lived in a small city and my Dad and stepmom lived outside of the city on an acreage, both in Treaty 6 territory. I was raised in the city and the country and learned to appreciate the different lifestyles of each place. After completing high school, I moved to Edmonton to study engineering at the University of Alberta. First-year was a grind, as is for nearly every first-year engineering student. Despite the intense workload I wanted to learn and do more work that served people, so I became involved with the Engineers Without Borders (EWB) student chapter and explored other social groups and initiatives on campus.

In my second year, I entered the mining engineering program. I became significantly involved with EWB for the next three years and served twice on the leadership committee. To

me, as a student, what I was learning from EWB was relevant to the engineering profession as I saw it. Yet, it seemed to belong to an entirely different world than my engineering program. My biggest takeaway from EWB was learning about the *why* of engineering practice: *why* are the designs so, *why* is the construction/building of things so, and *how* does it tie into societal values and goals to address root issues and systemic challenges? These learnings included critical analysis of the dynamics at the interface between design/technology and people's emotional, physical, cultural and mental well-being. I learned about the technical world of engineering and the social impacts and influences associated with engineering but separately, in different places, at different times. I desired more learning that integrated engineering practice's technical and social dimensions.

Another core experience navigating different worlds happened during my second co-op placement between 2nd and 3rd year. I participated in a UAlberta North fellowship, which brought me to live and work in Beaver First Nation (BFN), about 650 km North of Edmonton. I worked for the Band's Land and Resource Consultation Department and experienced a very different way of life. BFN, like many First Nation communities in Canada, heavily experienced colonial impacts detrimental to their humanity, and I argue to our collective humanity. The negative colonial effects were very evident to me as a white settler outsider living in their community. Oppression and assimilation were also evident in the government and industry negotiation meetings with the BFN Chief and council members, the latter who invited me to attend and observe. The learnings I experienced in BFN significantly pivoted how I viewed the world and my role in it. I realized how complex relationships are between big industries, the Canadian government, and First Nations communities, partially because the core values of each group are fundamentally different, and that there is fear that exists because of these differences.

In BFN I learned about people's ways of life, how they lived with and learned from the land, their guiding principles in life, their culture, which has evolved and adapted over millennia to exist and serve a purpose in the modern era. I learned that some corporate companies and industry representatives better establish and sustain respectful and reciprocal working partnerships across differences with First Nation communities than other. I also learned that respectful and reciprocal relationships benefit everyone involved; both groups learn and benefit from what each has to offer while maintaining their autonomy. The most significant benefits I see corporate companies realizing from a respectful and reciprocal partnership with First Nations peoples are more advanced visions and practices for sustainability, which includes a deeper relationship to the land, equity diversity and inclusion, and mental health. Again, what I was learning in BFN and the people there was very different from what I was learning in my engineering program. Deep down, I knew there was a connection between them but realized a significant amount of energy was required to build that bridge.

When I came back to Edmonton from my co-op fellowship with BFN I was compelled to contribute to bridging Indigenous and western cultures at the intersection of the resource industry and engineering. I gave presentations on my experience and what it meant to me as an engineering student to the senior leadership team of the University of Alberta, to a Faculty of Engineering alumni event, and at the university's 400th General Faculty Council meeting. I tutored and mentored three Indigenous youth from an Edmonton high school. One went into engineering technology at the Northern Alberta Institute of Technology. She didn't know about engineering until she met me and I inspired her to take the program. She is the first member of her family to go into post-secondary education. I am still connected to these three incredible, now young adults. I initiated and helped start up an Indigenous engineering student group. I did undergraduate research and produced baseline statistics over a 10-year time space on self-

identifying Indigenous student enrollment and graduation rates at the engineering undergraduate and graduate level. At that time, less than five years ago, there was approximately 1% of self-identifying Indigenous graduates at the undergraduate level. The statistics and associated demographics were used to improve the faculty's recruitment and retention efforts regarding Indigenous students.

I volunteered with UAlberta North, mentoring future cohorts of students. I attended campus cultural events such as Round Dances, public speaker series, and conferences related to Indigenous people's well-being and restored relations with westerners. I also sought out mining-related events and conversations regarding the working partnerships between the industry and companies, and Indigenous Peoples. I attended the Canadian Institute of Mining (CIM) Edmonton Branch meetings, the Canadian Mining games, CIM conferences, and CIM Environmental and Social Governance meetings. For my last work term, I worked at the Albian Sands mine near Fort McMurray for Shell. I must admit, at the time near the end of my degree and based on my engineering-related experiences with the mining industry, I was frustrated with the significant lack of reciprocal and respectful working partnerships that the mining industry had with Indigenous peoples and communities. I understand that both parties had to put in the effort to make things work, but I thought more could be done on the engineering side of things and that I had a role to contribute there. I decided I would have more success in pursuing this passion in grad school rather than going right into the industry.

The professor I did my undergraduate research with became the first-ever female Associate Dean for the Faculty of Engineering at the University of Alberta. I became one of her graduate students for a research project in environmental engineering that aimed to use and validate both western and Indigenous knowledge in addressing water quality issues. We were partnered with a local First Nations community. For eight months prior to any research taking

place, my research partner and I participated in community relationship-building activities. My graduate research partner identified as Métis and came from the Faculty of Science at the University of Alberta. We were involved with a community youth mentorship program for those eight months. It was a challenging but incredible time. It was challenging because life was tough in the community, and it was heartbreaking to see the resulting impact on the children and youth. I knew it wasn't the fault of their parents and grandparents. There were greater social and cultural-historical factors and corruption at play, marginalizing and oppressing these people from living a meaningful and healthy life. I learned the importance of meeting the community where they are at, and establishing a people-to-people relationship of trust before initiating collaboration on research planning and goals. It was paramount that the research contributed to the well-being and capacity building of the community just as much as it would for my research partner and me. You may find in this thesis a reoccurring theme of relationship to self, to others and to the land. One day when I was in the community, an Elder came up to me and said we teach our children and youth three things: how to have a relationship with ourselves as individuals, with each other as people, and with the land. Each of these three relationships are simultaneously independent and interconnected. The Elder's words have stuck with me ever since and is a framework I continuously refer to in my thinking.

In Spring of 2018, one official semester into my master's program, I took a leave of absence and never returned. Life presented an opportunity, and I entered a very different world once again. I was presented with an opportunity to work in Pairs as a high fashion model. I did not want to leave what I was doing with my master's work. My masters work was very meaningful to me because I was directly involved with relationship-building, knowledge exchange, and capacity building with the First Nations community members, youth and children. I did not want to leave them. My supervisor, a woman I look up to and trust, was aware of this,

and that to work in Paris is a rare opportunity. She encouraged me and supported me to go. Her support and encouragement was the deciding factor and so I went. Modelling is an entirely different industry than engineering; I found that out quite quickly. It was more spontaneous than controllable, elusive than structured. I lived in Paris for nine months and then Manhattan, New York, for five. It turned out I had a natural talent for being in front of the camera, and had a compelling stage presence. I thoroughly enjoyed the modelling work I did. I am grateful to have worked with many wonderful people from different classes and cultures around the globe.

I learned a lot of hard lessons in those 11 months of modelling internationally. Possibly the biggest was that I didn't believe in myself, I lost connection to who I really was and deeply questioned what I am responsible for in my life. In modelling, I faced a lot of rejection, as do many models, and gave all my time and energy to the industry until I was completely depleted of all my energy. I hit a point of rock bottom. I developed an eating disorder and became depressed. I knew I was getting into trouble; as difficult as it was to admit, I asked for help. The love, kindness and care I received from my friends, family, and professionals at this dire time, is something I will forever be grateful for. I have learned that my beauty, intelligence, and compassion cannot be taken away from me unless I give it away. Also, that I have a responsibility to use these gifts and talents for a greater good. Modelling internationally broadened my perspective on the world, humanity, and myself in a way academia could not. I currently still model but in a way that is beneficial for my personal growth and that is in service to a greater message for humanity.

I will now share the following five values that strongly influence my daily actions and greater ambitions. The first is reverence for all life. I have a deep respect for Mother Earth and all that exists within her: the water, land, air, humans, non-humans, and myself. Life is complex, interconnected, contradicting at times, and constantly in the flux of transformation. Negative

conflict and suffering are hard to experience but it is in these moments where we as people can deeply connect with one another. This is part of the transformational process that leads to positive and fundamental changes in our humanity. I strongly believe that there is hope for our humanity, despite our current and historical challenges and hardships, and that I have a role to play in this.

Individualism recognizes that even though we as people are interconnected, each of us is unique and has different natural gifts and perspectives on the world. I seek to recognize the unique gifts and strengths in each person I meet, even if they are not associated with society's narrowly defined metrics of success. Every person is also on their own journey, with their own lessons to learn and progresses according to their own cadence. I seek to recognize people as autonomous yet connected beings, respect them for where they are at, and do not extrapolate my observations of them to paint their future.

Love. It is hard to write a description of what love is. It is something we experience in being human whether it is with other humans or non-humans. It sustains us through our most complex trials and waves of defeat. The opposite of love is fear. Thoughts and actions, at the root, either come from love or fear. I am not perfect. Sometimes my fears get the best of me, and I do harmful things that require forgiveness. However, I try my best to be aware of the people around me, the land, the non-humans, and myself to not cause harm. Love is a core and radiant part of my being from which I strive to have my thoughts and actions take root.

Courage. It takes courage to be different in any way, even if that way is grounded in love and is for the better of humanity. It takes courage to share new ideas and to live according to an authentic version of self. It takes courage to be a whole human, to feel, to not to be ashamed of weaknesses and failures, and keep your heart open to giving and receiving love. Also, to walk

through the fire, my darkest moments, to be purified from what no longer is of benefit to me and to be transformed into a better version of myself.

Harmony and peace are what helps us to co-exist in non-dramatic and non-exhaustive ways with the chaos that surrounds us. Harmony is also a core part of my being. It helps keep my love steady and to stave the surprises that emerge to not overstimulate my nervous system and critical thinking. I admit that sometimes I am provocative and disruptive with the status quo, but, I try my best to do so in a loving, gentle way. It is my ultimate desire to contribute to greater harmony in my relationships with myself, others, and Mother Earth.

Limitations

The method used for conducting this research will produce usable results for faculty to improve the SL40 FN Design Build Course. However, the Shoal Lake 40 First Nation perspectives were not gathered and included in this research. Anyone seeking to do similar collaborative work will need guidance from their Indigenous partners regarding the best way to move forward together. Ultimately, other people are involved in this case study whose stories are not accounted for here, and further conversation with them will add to the account (Stake, 1995).

The case study method will produce results that are likely not transferable for other cases. A single case study research design is not a robust research method for producing transferable results about populations outside of the case (Stake, 1995). Furthermore, the thematic analysis will provide a detailed description of the case instead of detailing the nuances of particular themes therefore, some depth and complexity will be lost (Braun & Clarke, 2006). Merriam (1998) also supports this, who recommends the ratio between case description and case interpretations to be 60/40 or 70/30. This case study will be that of the later.

Choice of and application of theory also places a limit on this research. The theoretical framework used to analysis the collected data will influence the interpretations made and

therefore use of a different theory might produce differing results. Similarly, my background ground and life experience discussed in this chapter will shape how I interpret the data. Someone with a different background and experience is likely to have differing views and thus draw their own interpretations of what is presented in this study.

Summary of Chapter 3

To better understand engineering and architectural students' learning in the transdisciplinary SL40 FN Design Build course a qualitative intrinsic case study with a social constructivist theoretical framework has been designed and presented in this chapter. This research is focused on the students' learning as they engaged with each other, the university professors, Elders, and SL40 FN community members actively involved in the course. The four-credit, eight-week, SL40 FN Design Build course occurred in the Spring of 2019, where teaching and learning happened both on campus and in the Shoal Lake 40 First Nation community.

Ethical considerations are discussed for participant recruitment, data collection, storing and managing data, and lastly, analyzing and presenting the data. It is paramount that this research does not cause harm to the research participants and the people involved in the SL40 FN Design Build course. The course is a teaching and learning environment at the intersection of western and Indigenous cultures, thus research pertaining to the course requires cultural awareness, sensitivity and cultural safety mechanisms to mitigate miss-communication and harm to relationships. My supervisor, my advisory committee members and I are all educated on Canada's colonial history and the destruction it has caused to the people who live and depend on this land. We all seek to continue in changing and bettering our practices within academia and our professions to create more peace, harmony, and alliances in the divides between western engineering and architecture students and our Indigenous partners and neighbours. This is lifelong learning.

The primary audience for this research is engineering and architecture faculty and staff, and the participants in this study largely identifying as western or as newcomers, educated in a western system, and therefore the research is conducted in a western way. This research is only part of the story of the SL40 FN Design Build course. It is meant to familiarize the reader with its uniqueness and to provide space for the reader to draw on their own background and experiences as they reflect on engineering and architecture education that prepares students to respond to wicked problems.

Chapter 4: Findings

The findings are presented as a narrative case study detailing students' learning journey's in the transdisciplinary SL40 FN Design Build course. The case study, created according to the data analysis method described in Chapter 3, tells a story about the collective learning activities and outcomes in chronological order of the design-build course: Week 1 day one, Week 1 Elders' teachings on campus, Week 2 first visit to Shoal Lake 40 First Nation, Week 2-5 conceptual design, Week 5 Freedom Road Powwow, Week 6-7 prefabrication, and Week 8 the build. Photographs from the course can be viewed in the SL40 Design Build Instagram account (@Shoallake40designbuild). Multiple perspectives regarding the student's learning experiences within the collective activities are voiced. Quotations from the research participants were selected to represent the multi-voicedness present in the dataset. To protect participant identity the narrative was written with importance placed on what was said and not who said it. Examples of the coding, operationalization of the CHAT activity system and development of the narrative case excerpts are provided in Appendix F.

The Case of Engineering and Architecture Students' Learning in the SL40 FN Design Build Course

Week 1: Day one

9:00 am marked the start of formal instruction (Field Notes), initiating Instructor 1 and 2 to teach together for the first time. A diverse group of engineering and architecture students dotted the room; "a lot of big personalities" (1 Field Notes). Instructor 1 introduced the SL40 FN community, the challenges they faced, and the intent of the class's partnership with the community.

We received a brief history of Shoal Lake 40 First Nation and Freedom Road from Instructor 1 and a classmate. This was followed by research to learn more about the community and the hardships that had been brought up. (Owen portfolio)

The relocation was the initial factor that set the community back. By being relocated, the community had only water access. This meant in the winter on an ice road and in the summer with a barge. During freeze and melt, it is very dangerous to travel on the ice, sometimes resulting in death. Another setback that the relocation caused involved infrastructure, because there was no road access, building infrastructure was a difficult task. SL40 FN has been in need of a water treatment plant for many years. Because of the difficulty of building with no road [in and out of the community], this project had not been completed. (Dana portfolio)

So, the fact that we got our water from Shoal Lake was definitely an awareness I had, but the fact that SL40 FN did not have access to clean water was something that came around with the course. The issues were brought to light, and a lot of us were strongly appalled by the fact that why can't you get clean drinking water to the place that provides almost 1,000,000 Manitobans with clean drinking water? (Liam interview)

Freedom Road marks a milestone in a battle with the governments that have lasted for many years and caused lots of trouble. (Owen portfolio)

I knew about Freedom Road beforehand, and I think learning about Freedom Road and the importance of Freedom Road and the actual impact that project has not only on Manitoba and Ontario but all of Canada and, in fact, all of the world for how significant that project

> was for the governments to acknowledge the harm they did and that it was their responsibility to do something about. (Rebecca interview)

The students acknowledged the government's role in the harm they caused SL40 FN over the last century. Realizing how infrastructure development can promote inequality, several students initially focused on understanding how they could help resolve resulting hardships the community faced.

> We sought out at the beginning of this project to help the community heal from the struggles they faced over the last hundred years by building a structure where all types of people are welcome. (Liam portfolio)

Several students viewed their involvement more as efforts towards reconciliation, a partnership towards growing, healing and benefitting together. A mentality that does not hierarchize settler people over Indigenous people.

> Freedom Road and this design build project can represent so many things for so many; resilience and strength of community members, trauma and devastation that the Winnipeg Aqueduct and lack of road have caused, and now the growing partnership between Indigenous and non-Indigenous peoples of Canada. (Rebecca portfolio)

Other students were in-between these two stances making sense of how engineering and architecture designs and actions can cause division among groups of people. Overall, and among the students, more thought was placed on the immediate hardships and challenges resulting from colonization rather than questioning the motives and beliefs driving colonization within a historical context.

> The key reasonings for why many of the challenges Indigenous communities face should have been addressed. Although, Shoal Lake 40 First Nation and Freedom Road are exemplary cases of colonialism and what it has led to; the greater understanding and depth of colonial history (treaties) should have been touched upon as well. Growing up in the late 90s and early 2000s in Manitoba the true history of colonialism was never provided. Although, even with sufficient post-secondary education such as a Native Studies class, no non-Indigenous person can ever understand the effect colonialism has had on Indigenous communities and individuals. (Rebecca portfolio)

> *I think it is a responsibility to understand place, we did brief the history and stuff of SL40 FN, but no the students' don't understand that Indigenous people were forced and pushed out to the really crappy parts of the land and they were separated and weren't allowed to do ceremony, they had to hide it in the bush, the students didn't know that stuff. (Instructor 1 Interview)*

The focus was not yet on learning how beautiful Indigenous ways of being are. If you can value the beauty in a way of being, in people, you don't want to destroy them.

> *So also not just talk about the bad things, bring in literature and readings that talk about how this Indigenous way of thinking is beautiful. (Instructor 1 interview)*

Week 1: Elders' teachings on campus

On campus, Elder Meade and Elder Carl Stone provided prominent cultural teachings that introduced many of the students to Indigenous ways of being and living in the world. These teachings included the medicine wheel, and values of kinship in the "7 Sacred Teachings of Love – Respect – Courage – Honesty – Humility – Wisdom – Truth" (Liam portfolio). Furthermore, they shared information on the protocols of water stewardship, passing of knowledge and gender identity and roles in Indigenous traditions. At Migizii Agamik, the Indigenous Student Centre, Elder Carl Stone taught about the building's culturally significant architecture and how traditional knowledge is used in contemporary design. He discussed how the orientation of entrances and rooms was selected and based on cultural teachings of The Four Directions and connections to the environment. The Elders were viewed as wise knowledge holders whom students "partook in consultations with" (Liam interview) and learned from. The Elders' teachings mediated the non-Indigenous students' understanding of Indigenous peoples and perspectives. Some students began negotiating their western engineering and architecture understanding of design.

> *Talking with the Elders and getting to know their perspectives and even when we were getting a tour of Migizii Agamik it was a way that we were able to learn from them and how they talked about things, how they talked about the different meanings of things, and the importance of a house or things designed to reflect on the culture, specifically when we were looking through the building and talking about the different entrances and how you enter the building and certain rooms. Also this kind of connection to the land which was*

> *really brought through the whole course. I think in general before taking the design-build course there weren't really any mandatory courses that kind of touch on any of these kinds of ideas which I thought was really interesting. So the Elders taught us to think about things a little differently than how we would usually do and that made me give things a little bit more thought. (Kai' interview)*

One student realized that the cultural teaching shared by the Elders on campus, although valuable, may not entirely or even partially be reflective of what is valued by the members of a certain Indigenous community. Therefore, learning from the people of SL40 FN directly would be essential. Some students were motivated to listen to these new teachings from Indigenous culture and design when they were connected to the people the design process was serving.

> *It was a surreal experience, being able to listen and appreciate the cultural values and teachings that are so important. Gaining a better sense of the way stories, lessons, values and so on are passed on to others, and our group. It was a reminder to all of us that this was for real people. (Owen portfolio)*

Beyond sharing culturally relevant and practical design aspects rooted in Indigenous ways of being, the Elders' helped the students reflect on how their identity could influence their interactions with members of SL40 FN. When sitting in the circle room at Migizii Agamik Elder Carl Stone created a safe space for students to ask questions. One student asked how they could feel comfortable going to SL40 FN. Elder Carl Stone responded to the student's question with a lesson and said, in a gentle and chiding way, "it's not about you, the people have to feel

comfortable with you, and that you will know" (Field Notes). The student's question and Elder's answer spurred students to acknowledge any fear they had regarding their privilege:

> I was apprehensive because oftentimes we get negative connotations, for almost like a white supremacist type of belief, that often propagates throughout media and culture today, and then that sort of belief getting put on myself, so how do I separate myself from that? And then how do I go out to the community and just be open and caring of all the individuals around me? (Liam interview)

This question and answer also provoked students to look at any fear they had interacting with a First Nations community for the first time.

> I haven't had this experience of dealing with any sort of [Indigenous] community, so I had a fear of not being prepared enough where I might offend someone by doing some kind of action or saying something that is not accepted. (Kai' interview)

The students were influenced by Elder Carl Stone's teaching to reflect on their identity by questioning how they embody western worldviews and how they would be perceived, as a group of non-Indigenous university students, by members of SL40 FN. These reflections and associated negotiations of identity were not explicitly discussed as a class. The students contemplated this individually on their own time.

> I started to think about the bigger and bigger and bigger picture, a bit more like what Canada really is or all the things we are part of living in a city in a society. (Owen interview)
>
> I was trying to understand how I fit into the community and was told sort of that the community will accept you just as you are so long as you're not blatantly disregarding

> *their types of culture and beliefs, like if you go in and just be yourself and [you are] positive and a good individual then the community will reflect that back on you, and that was essentially what Elder Carl Stone was talking about when we were discussing. (Liam interview)*
>
> *The colonist mentality that it is the responsibility of Indigenous people to make the non-Indigenous people feel comfortable on their land is an ideology that Elder Carl Stone established early on in this project as inappropriate. Firstly frame yourself as a guest, understand the context and the history, and then go from there. I think the Elder provided a really good response to that individual [who asked how to feel comfortable in the community], and it wasn't aggressive or attacking at all. You have to position yourself. (Rebecca interview & portfolio)*

The students, initially concerned about offending or causing harm to the SL40 FN community, were motivated by the Elders to learn how to show up in the community and respect their way of life.

> *The Elders helped me get over an initial fear of interacting with people in communities that are suppressed or had a lot of difficulties. Especially [because of my privilege] I want to be really careful and thoughtful about how I act and do things, so I think it took some of the pressure off in a sense or made it easier. I just felt welcomed in a sense to try and be better about a lot of things. (Owen interview)*

The Elders' teachings on campus helped prepare the students to have a community-based design mindset by highlighting the cultural context and identity work required to respectfully meet with the SL40 FN community and to collaborate on a shared project.

> *Non-Indigenous peoples of Canada must learn how to decolonize their actions and sense of entitlement in all scenarios, specifically within a project incorporating Indigenous and non-Indigenous partnership. This perspective is essential for creating a collaborative relationship.*
>
> *(Rebecca portfolio)*

Week 2: First visit to Shoal Lake 40 First Nation

The class travelled 2 hours from Winnipeg to Shoal Lake 40 First Nation in two vans to meet with the community lead, Roxanne Greene (now Roxanne Balan), and community members, and to visit the location of the project site. Being in a First Nations reserve, as guests, was a new experience for most of the students and culture shock was experienced. Some of the students expected the community to resemble what they had learned in high school history class.

> *I was having some shocks you know culture shock. Like this is not going to sound too well but how modernized the reserve is. I thought in the reserve people might still be trying to stick with most of the traditions that their ancestors have passed on, and you make a lot of stuff from hand and off the grid. I think the Ojibwe, the SL40 FN reserve was off the grid, but the community was able to find their way out to make their life easier with some other options. I think my first expectations were I would see more traditional clothing. And that the community would look more historical, maybe have*

> *some really old buildings. Because before that all my impression of an Indigenous reserve came from my high school history class. (Jrayanna interview)*

Being in the community and feeling shocked about the unexpected environment, and ignorant about their lack of knowledge encouraged the students to explore why they had gaps in their prior ideas of Indigenous peoples and cultures. One reason for the gap in knowledge was that the information the students previously heard regarding Indigenous communities was inaccurate or was a very partial and uncontextualized representation. The students had a "hands-on look at some of the actual problems as seen in the news but being in person in the reserve interacting with the people living there it was a lot more real" thus providing contextualization to previous piecemeal conceptions (Owen interview).

> *The facilities the community had aren't as up to par as I thought they would be. I've never spent a lot of time on a reserve so I don't know how to word it correctly but I hoped that they would've had better facilities than they did... When you go there you understand it more. It makes more of an impact on you. (Dana interview)*

> *I started to realize that yes the struggle is real and this is something the whole society needs to know, everyone should know about this and try to think of a way to address this because it's unfair. (Jrayanna interview)*

> *I think it's really important that if a student's coming to visit any community whether it's Indigenous or not that they go with an open mind and really try to learn from the members of the community because it's so easy to go in and be like, I did my research. (Dana interview)*

Roxanne led the class down to the beginning of Freedom Road, to the site of the project, with a community knowledge holder to participate in a traditional drum ceremony to bless the land. One of the course instructors had been learning about the cultural protocol for ceremony and "if it wasn't for her there would be no skirts" for the women to wear (Instructor 1 interview). In order "to be respectful of their culture, if we're going to a ceremony us women need to wear long skirts" (Dana interview).

> *We were running around getting the skirts for women in the middle of the road that was not prepared, haha, I mean we were prepared partially because somebody remembered to get them but we were not prepared knowing when to put them on. (Instructor 2 interview)*

Through the disorientation, the community knowledge holder began to lead the group in a ceremony and tobacco offering. For many students, being present in the ceremony, at the beginning of Freedom Road, was first and foremost an emotional experience.

> *I'm quite an emotional person. I think one of the most emotional experience for me was when we first went to the site. We were walking up the road and one of the community members was telling us the story of the land and the community, we were near that bridge that they had built over the canal that had been dug [turning the community into an artificial island]. Then he had done a drum ceremony type thing and sang for us and then he gave each of us some tobacco to spread into the land and that was the first experience with the community and it was really an emotional thing. (Kai interview)*

> *We did a drumming ceremony to bless the land. That was pretty powerful because I had been to SL40 FN before, so I kind of had interacted with the community before but we never did any blessings. I thought that was pretty special to be welcomed in and the community welcomed us and let us partake in that ceremony. (Dana interview)*
>
> *To me that was just explosive, like I can tell almost everyone on the team was emotional at that moment, and that was the point of connection to me. He [the community knowledge holder] opened his voice to us. He opened his heart to us. It was very powerful, very powerful, and I think he knew what he was doing. (Instructor 2 interview)*
>
> *There's just something about a good drum song, it made me feel at home. (Rebecca interview)*

The knowledge holder's presence and drum song ceremony brought the participants close to something within themselves they held in regard as special and touching. They compared the experience to being moved by music, feeling a sense of home, or witnessing something powerful. This emotional stirring was more unconscious but was enough for the students to be moved and find a common point of connection with the community member.

> *I was hoping that the students would be moved and buy in. That's what I really wanted. That's why I felt like having the knowledge holder with his drum and engaging with the students was really important. (Instructor 1 interviewer)*

The point of connection established between the community knowledge holder and the students was transformative; "it opened my eyes to the reality of community engagement and how that

would actually work" (Kai interview). The students shifted their prior perspectives and understandings of what it means and entails to engage with the community members.

> *Learning about the traditions of tobacco and the history of the land helped to build up the respect and understanding that was required to work on a site that had so much meaning and purpose. The act of offering up tobacco after listening to the traditional songs and drumming was a very moving moment that was really the start of a completely new outlook on nature and set the groundwork for the rest of the project. (Kai portfolio)*

> *We were throwing tobacco to the woods before we started the construction, so we had a ceremony before we started the construction or before we actually went in the woods and invaded some of the sacred places. In my culture we have that same kind of thing, when we start a new project we need to have a ceremony to appreciate what we have, to appreciate the opportunity for the new development and that it is for the sake of people. So I was like wow we do this as well. (Jrayanna interview)*

In leading the ceremony, the community knowledge holder provided the students with guidance and meaning on their responsibility in this new partnership. Some students recognized the depth of knowledge held by the people and land of SL40 FN and desired to spend more time in their presence learning from them.

> *We did have a really nice little ceremony when we first got there so that brought more perspective and awareness to the whole project, but there definitely could have been a lot more I think. There were talks about Elders checking the land for us to know that the*

> project was okay. We never got to meet or hear from the people doing that important work. Also, I just wanted to spend more time on that exact site. (Owen interview)
>
> When you arrive to a place it's about listening it's not about engaging right away. If you read Braiding Sweet Grass by Robin Wall Kimmerer she mentions that one of the greatest things that we can do is to take time to understand. (Instructor 1 interview)

The students, with some preparation the week prior from the Elder's teachings on campus, showed up in SL40 FN respectfully and began to understand the people and landscapes there. The community knowledge holder leading the ceremony met the course participants with great trust. By the end of the first visit the students gained an emotional and energetic connection to the lands and the people of SL40 FN. They felt welcomed and accepted for who they were as outsiders to the community and encouraged to journey further along in making sense of their roles and responsibilities in this newly emerging project.

> From day one we told the students this [work] is not something that we're imposing to the community we're going to the community and listening to them and we're asking what is it that they want us to do for them and maybe they will say nothing. A key factor was trust and acceptance from the community because without that nobody could do anything. Everybody [the students and the community members involved] was ready to express ready to share and ready to learn [from one another]. (Instructor 2 interview)

Week 2-5: Conceptual design

The students returned to the architecture design studio on campus with a lived understanding of the SL40 FN community and the community's desire to build an outdoor feasting shelter at the beginning of Freedom Road. The class was asked to organize themselves into three groups with a mix of architecture and engineering students to begin conceptual

ideation following the architectural design process. Brainstorming and conceptualizing side by side was a new experience for the students, resulting in them bringing/confronting stereotypes between engineers and architects.

> *Somewhere throughout the engineering degree you just get this understanding that apparently engineers and architects don't like each other on a professional basis or they have qualms in terms of their design ideas and how to appropriately design a building to weigh the aesthetics against the practical and stability requirements. (Liam interview)*

> *I often joked that architectural features were just sprinkles or the cherry on top of the design. (Rebecca portfolio)*

The architect students led the groups in the design development and design charrettes. Drawing and modelling ideas was a foreign concept to the engineering students. An engineering student commented, "you have to remember that I am an engineer and I have no creativity" (Field Notes). Another referred to the design process as "arts and crafts" (Field Notes).

> *The engineers really didn't understand the initial modelling…it looked like they hadn't touched glue and popsicle sticks in 15 years. (Dana interview said jokingly)*

> *As engineering students, we never had to do any models physically by hand. We were handed some of the materials and they were telling us to go ahead make your model, show us your design, show us your ideas. I was like what? Because I have no idea what you want me to do here. If you want me to make a model of a shelter then I'll make a rectangular box. (Jrayanna interview)*

The architecture students were more conceptual with a holistic approach to design that considered the environmental surroundings and feeling of the feasting shelter. To the engineers,

this way of thinking was abstract, not black and white. Engineers are taught to think in binary numbers, about stress, strain, force, physical safety, and computer modelling, so "how do I make this building have a meaningful appearance?" (Jrayanna interview).

> Engineering students think differently than architecture students that's just how our education is and what you're taught. (Owen interview)

> From my experience with the engineering students they were thinking more numbers and force flow diagrams. (Dana interview)

Although the engineering and architecture design process is different, some engineering students had excitement and a real desire to learn from the architecture students' process of design.

> The ideas were bumping together… I found it exciting to be able to see how other people think and to be able to learn more about other disciplines. (Jrayanna interview)

> In the first group, there was a real sense of group work. The engineering students really jumped into the work both feet, visualizing the people in the space & the connection of the building to the site! (Field Notes)

Some engineering students were more resistant.

> I think a few engineering students were just probably thinking "this is stupid, who does this, it's a piece of cardboard, what is the meaning of that?" (Instructor 2 interview)

> In the second group, only the architecture student spoke. It was difficult to get a sense of whether the engineers participated. (Field Notes)

Eventually, the student groups progressed through their disconnect in understanding each other as they asked questions and provided perspectives and discussed problems and solutions on how to incorporate their previously learned cultural teachings from the Elders on-campus and SL40 FN community. The course instructors, who valued interdisciplinary learning, visited the groups

and assisted in facilitating the conversation. However, most student leaders in each group facilitated the discussions.

> *Many of the ideas focused on the visual elements of the teachings and incorporating them into the design. The interaction between the building and sunlight, water (both rain and Shoal Lake), and humans formed the interpretations of the structure. The use of wood framing, fabrics, building shape, and location on the site lead to the first iterations of the preliminary building models/designs. (Rebecca portfolio)*
>
> *Elements of our design came from speaking with the community members about the space they envisioned. One of the important elements was a space to gather for the whole community, including old and young. This meant the structure needed to be accessible and provide shade for Elders, but also a place for children to play. (Dana portfolio)*
>
> *Our end design consisted of seven sections for each of the Seven Sacred Teaching…Love - Respect - Courage - Honesty – Humility - Wisdom – Truth…and attempted to embody a connection between the sky and earth with a straight line of sight to the water. (Liam portfolio)*

As one student discussed the student-centred approach of the design studio:

> *Worked positively when you have the leaders within groups to facilitate and ensure that opinions are being heard, shared and valued equally. You can hit significant roadblocks*

when you don't have individuals who are willing to lead those types of conversations. So I think communication largely was successful because we had numerous strong leaders within the group and I think that you get strong leaders in the group because the course is an elected option; students are making a choice to be there. They're interested in the outcome of their own learning experience and it usually just attracts students who are more passionate about what they are trying to learn. Like there's individuals in the course who are more quietly spoken but had really good input that you sometimes wouldn't hear about unless you had someone making sure that the conversation was being directed in the right ways. (Liam interview)

The engineering and architecture students worked side by side on design development. The students were motivated to work through difficult moments and communication challenges in understanding the other discipline because of a shared goal to create a design that met community needs, structural principles and aesthetics. Many students genuinely wanted to understand the other disciplines' perspectives and, in doing so, tried to adapt their ways of thinking.

We had to learn how others thought and worked and adapt ourselves to mesh well with others. I had the chance to understand them better, and they had the chance to understand me better. (Dana portfolio)

The students began to learn how each discipline approached design work, what they considered as important, differences in creativity and how to design together.

There was a lot of learning and understanding what an architect does and what an engineer does and finding that they both have their role to play and can come together

in a really meaningful way. That's what I would say is the whole idea of collaboration. (Instructor 1 interview)

Two very different ways of thinking quickly began to merge one as the architects realized how are we going to construct that idea, and as the engineers realized how is that structure/feature going to make the person within it feel. (Rebecca portfolio)

I think the moment we finished the model and looked at it from different angles and took pictures of it with a fake tree right beside it that the engineering students learned oh this is why they make models it gives you a feeling very close to reality, a feeling of what this building is going to look like... I think the physical model is different than if you render something on a computer...the students learned to see a design process through a different lens that they've never experienced before so this was a different way of thinking, a different way of design. (Instructor 2 interview)

Week 5: Freedom Road Powwow

The class was invited by the community to attend the SL40 FN Freedom Road Powwow. Again, they travelled two hours by van to SL40 FN. Attending a powwow in a rural Indigenous community was a new and impactful experience for the majority of students.

It's just really powerful to have a culture accept you in and invite you, and for them to share their powwow with this random group of students from Winnipeg, I thought that was pretty special for the community to do for us. (Dana interview)

The powwow was super nice because that was my first time to attend anything like that. I love music I am passionate about music so when I heard the music they played,

I'm not sure if they have another name for it I'm just gonna call it music, when I heard the music they played like I don't know their language and I'm from a total different culture but I can still feel the connection cause it's just a common language and the music is just so beautiful. (Jrayanna interview)

It was powerful to see how every generation was a part of the celebration it didn't exclude anybody everyone was part of it and like the regalia and the food and how extravagant it all was. They gave out gifts, they're such a giving community, and we had lunch with them so that was really special. It was pretty amazing to see it all and to be a part of it. (Dana interview)

The men were drumming all day and there was this one little two-year-old who was running around with a drumstick and drumming on beat with all of these older men. It was the most beautiful thing ever to see this little two-year-old who can barely walk being able to keep up with these men and drum on par with them, it was amazing. That baby is just born and raised to drum. (Rebecca interview)

I'm attending the ceremony and seeing a different type of culture and I'm actually able to see how that affects the younger generation and I think that was really key to me because it was positive it was happiness it was exuberances from the younger individuals and kids who were partaking in it. (Liam interview)

By being present in the welcoming community of SL40 FN the students had space and opportunity for causal interactions with the community members.

> *A community member talked to us about a lot of different things and it was cool to have a more casual conversation and not like this is what we're doing and this is the design and stuff so more casual conversations I think provide a lot of value and like that's the thing you're going to remember, you're going remember the random conversation like the little boy dancing like that's what sticks with you and not the comment on the design in a way. (Dana interview)*
>
> *I was with one of the Elders who was watching the baby drummer by the water and talked to them for a bit. That was very memorable because we were just looking out at the water and they were telling me a story about the old barge. (Rebecca interview)*

The in-person experience at the powwow helped students learn more about the communities culture.

> *I dipped my toe into learning a little bit about their ceremonies and I thought that was really special because reading about them and watching them on YouTube is totally different than experiencing them…Experiencing a ceremony is the best way to learn about a culture you are not familiar with. (Dana interview & portfolio)*
>
> *I felt more understanding of their traditions and their knowledge in terms of what their environment is like and what they hold as important within their culture. It sort of just comes across to you as you're watching them and they're dancing, the movements and*

> the drumming, you get a feel for the connection between earth, water, sky, and everything throughout the course and how their values are lived. (Liam interview)

After the powwow the students had a spontaneous opportunity to share their drawings and models of the feasting shelter with community members for the first time.

> We popped open the back of the trunk and pulled out some drawings and models just as people were leaving the ceremony, some took a look to see what was going on. The children were looking and playing with the model and it was a really nice interaction, kind of a pseudo-presentation of what we had made and in a way it ended up being a lot more community related than I guess we would've thought at the time. (Kai' interview)

The students appreciated the feedback they received on the design and wanted to have more time designing and interacting with the community. However, it was difficult to achieve with the significant time and distance barriers.

> Does everyone really want this project? Or like having all these outside people do it for us? It was a bit of mixed emotions from that day. Most of the project was done in the city...It would just be so nice to draw more with the community or pay more attention to the project and the context at the site. (Owen interview)

> We were pressed for time we were a couple hours away from SL40 FN so when we did have meet ups they had to be arranged and planned, and I feel like some of the best stuff doesn't really happen when it's arranged or planned, and it just happens

> organically or naturally, so, of course, the distance from SL40 FN didn't enable that to happen, so there was only like a handful of times were we presented our design and then we got to go ahead. I think definitely there needed to be a lot more studio [design] work with the community. (Rebecca interview)

The welcoming and accepting community members and the vibrant activity at the powwow provided the students with a rich cultural and introspective learning experience. The students felt a true sense of connection with the community, some more than others, but all wanted more. They began to realize the value of this type of engagement and how the information they received are related to the design process. Several students saw how the SL40 FN culture is central to their lives and how much they valued their own culture. This influenced some students, with western cultural backgrounds, to reflect on the legitimacy of institutional prejudice and racism.

> *Being received positively by the community and making that comfort with you is inspirational in a way, like I'm feeling inspired by the people who are around me because they're accepting of me and the type of individual I am, so like what is this big issue around institutionalized racism? Why do we judge Indigenous individuals for certain types of decisions like what is so different between us and them? (Liam interview)*

At this point the students also began noticing a tension between western rules of time and the nature of time in relationship-building with the SL40 FN community.

Week 6-7: Prefabrication

Prefabrication of the design involved bringing the detailed design to its built form relying on the construction drawings previously made as well as organizing the supplies and equipment for the components to be transported and built on site, all in a safe and reliable manner. The goal was clear. The start was slow. Many students were unfamiliar with the practices and techniques of wooden frame construction and prefabrication and thus experienced frustration and feelings of discouragement.

> *The nature of students is that we are not that practical we don't really do things that fast we're not really experienced. (Jrayanna interview)*

Some students never held a drill before and didn't know how to hold a hammer. Furthermore, this type of build was new to the course instructors. The prefabrication shop manager and prefab expert external to the university provided guidance on how to precut columns and beams and plan the construction details.

> *The prefabrication process began by splitting up into teams to overlook certain areas of construction. There were individuals working to complete the panel sections, fastener adjustments, collar tie and shoe painting, lumber cutting, and blocking. The layout process and methodology in deciding how to erect the structure was put together in seven sections. Each section would be assembled on-site and then lifted into place. Assistance was received from a prefab company to plan our execution. (Liam portfolio)*
>
> *The prefabrication experts brought fresh eyes into the initial stages of the build. They provided wonderful basics on framing for the class, they provided insight into how we can actualize our design, best methods for the frame connections and the construction process. Trade*

> tips such as measuring three times, marking the wood with a specific sweep, discussion on cutting on or after the line drawn, and organizing the cut pieces of lumber. They provided advice to the CAD design team on connections and methods of construction as well. (Rebecca portfolio)

> When we were making cuts it was stuffy inside and the weather was all over the place so we took the saw outside to make some cuts. The shop manager came by to say, "mhhh that's not gonna work you're gonna have to redo those cuts". I didn't realize it at the time but I was cutting on an uneven surface and so I'm making mistakes. (Liam interview)

> The most frustrating part, there wasn't enough space. It was nice that we could be outside doing the work and it was enjoyable but trying to level the saws out so our cuts were straight and building our swinging panels we didn't really have a flat surface so it would've been nicer if the pre-fabrication space was a little bit larger but maybe that was the scale of the project instead of how large the space was. (Dana interview)

Elder Meade visited the prefab shop to monitor and check the design progression; it was "valuable to get his approval" (Kai interview). As students learned from and engaged with the prefab experts and started to assemble their design, they realized that certain aspects were not going to work. Movable panels were designed to act as doors for the shelter, opening and closing to accommodate changes in weather conditions. The first panel was prefabricated and tested for its ability to open and close.

We designed these panels that would be between the columns. The panels are what I worked on most at the design stages and it didn't translate from small scale to large scale as we imagined it would. We wanted them to rotate vertically and we did a full-scale and we were like wow that's way too heavy that is not safe at all... even though the engineers did calculate all the loads it didn't come out as we expected it would. (Dana interview)

It was pretty stressful trying to make those panels. They didn't end up working as originally designed. That was heartbreaking because it was such a fun idea. We were building them and designing them and were like these doors are not going to work because I can just see them getting left open and then the winds going to rip them off or some kids going to get hurt because they are going to be swinging on them. Cool great idea unfortunately for the site away from the community away from any sort of supervision it's not the best idea. That was one heartbreaking part. (Rebecca interview)

We designed the panels in the studio on computer, but we never thought of how the panels will be opened or lifted in daily use scenarios. (Jrayanna interview)

I think that was really important for all the students to realize sometimes you got test things out to see if it really works. (Dana interview)

The discovery of the panels not working created the challenge of adjusting the design on the spot. This brought everyone together to brainstorm, problem-solve and find a way forward.

> *If we change the panels from going a vertical rotation to a horizontal rotation how does that affect other parts of the design? For example, the height of the design was determined because we thought we were rotating vertically. The panel rotation change really affects everybody down the road even though people are on different parts of the project so everyone came together to brainstorm different ways to make things work and test them out and that was a cool opportunity. (Dana interview)*

The collaboration among the students, instructors, and prefab experts increased as the work progressed. Students came out of their shells and began to feel more empowered using construction tools to build the design.

> *The prefabrication was a transitioning point for allowing people to come out of their shells and to work and get comfortable with the tools and also just get comfortable with being on a construction site. It was an empowering experience to be able to use all the tools and have the trust from everyone to do all the things I did. (Rebecca interview)*

The course instructors, aware that the experience was new for the students, tried their best to create an open environment for students to ask questions and not feel ashamed of making mistakes. Everyone made mistakes in translating the design to the built form and learning from mistakes was essential for reaching their goal of creating a safe and reliable feasting shelter. The

students were excited to see the design come to life when the first of the seven frames was completed.

> *When we put up the first bent [frame] of wood, wow were the students excited, because what they drew and what they were staring at in a computer came to life and it was actually quite grand. They worked together to make this thing so that was really nice too. I think there were a lot of lessons in collaboration, students being leaders in their own specific tasks, and asking questions. (Instructor 1)*

By the end of prefabricating the structure, the students learned that when translating their design to full scale things don't always go as planned and that errors are unavoidable. The students also learned the importance of practicality in making ideas come true. Such as requirements for daily use of the structure on site which influences what is practical and what is not.

> *One will not be able to consider all aspects of assembling and construction when sitting in front of a computer and just model your design. You will have to be physically at the site to see how the design will be put into reality and what kind of assembling/installing/building difficulties you will face while making your ideas come true. (Jrayanna Interview)*

Some aspects of the design had to be forfeited due to time constraints. An originally designed canvas covering over the wall panels never got added even though the material was procured.

Week 8: The build

The students and course instructors eagerly arrived at the construction site in Shoal Lake 40 First Nation with a "sea-can containing the pre-made panels, pre-cut lumber, collar ties, shoes, all necessary tools, and scaffolding" (Rebecca portfolio). Behind schedule and out of budget the build was moved a week later than planned. Despite the change in schedule all the

students in the course were able to participate in the building of their design with the Shoal Lake 40 First Nation community.

> *Our timing didn't match the community timing, our speed didn't match community speed in terms of doing things and getting things done. I'm not saying who is faster who is slower it's just how things work. So although it had caused some delays on our side we were totally ok with that because we knew things work differently within different societies in different communities. We were just happy that we could finish what we were planning to do. (Instructor 2 interview)*

This time the students and instructors would stay in a construction camp set up by the community for 5 days. On day 1 of the build, the weather conditions were not favourable. The task was to ensure the prefabricated structure will fit together on the recently poured concrete pad. Even with the looming pressure of a demanding project, the group was hopeful and expected a smooth assembly. However, unexpected construction problems were quickly realized. Since the concrete pad was not prepared according to design requirements the metal column anchor brackets had to be attached to the concrete in a different way. The group had "challenges with drilling into the concrete, [they] didn't have the proper drill bits" on-site with them to accommodate for the unexpected change (Dana interview).

> *It is 40° plus it is super humid, you're tired, the sun is burning your shoulder and you're drilling into concrete and it doesn't work (laughs). (Instructor 2 interview)*

Planning how to assemble the prefabricated structure on site was a big challenge for the engineering and architecture group. They were unsure how to proceed.

> *It took us multiple days on-site before we even had any of the columns upright because it was so much planning and placing them on the [concrete] pad. Trying to fit all the prefabricated pieces together didn't go as smoothly as I thought it would. I've worked in construction before but never with a group of engineering and architecture students. I was a labour right so I was just helping and this one we actually got to do it all so it took a little longer than anticipated. Also, you begin to realize what's important and what isn't important. (Dana interview)*
>
> *It took us so long to figure out if the concrete was actually straight and if everything was actually measured properly and [if] we had actually made all the lines properly because we drilled into the concrete [pad] and we put the metal [brackets] down we wanted to make sure that everything was going to fit together afterwards. (Kai interview)*
>
> *It was a high-stress environment because we were short for time and all of us didn't know what we were doing. (Rebecca interview)*

A reason for slowed progress and challenges faced is that the students and the instructors did not know how to translate their design into its built form.

> *The instructors are super smart and amazing architects and engineers, but they don't go to site and build what they draw (Dana interview).*

The university group could no longer rely on their computer models, construction drawings, calculations and detailed designs for guidance on how to physically put the pieces together. This was a significant perspective-making moment for several students who realized how design

elements can be redundant and that "you can't predict everything" that is going to happen in the real world (Owen interview).

> *It was definitely a learning experience for the students and the instructors. Maybe we didn't need to plan in that amount of detail (chuckles) and maybe it's more important that we know how to put things together in general. Your profs don't know it all they are learning with you they're there brainstorming with you and sometimes they come up with an idea that doesn't work and that's ok because that is how the world goes. (Dana interview)*

As a result "there was a good day or two that we had been [on-site] by ourselves without the community helping us and I think we were a little bit lost" (Kai interview).

> We had to like re-assemble [the prefabricated parts] multiple times on the ground because none of us knew what we were doing. (Owen interview)

After a couple of days being feeling lost, frustrated, worried, and under pressure the community builders arrived. This was the first time the students and the community builders met each other; both groups were shy.

> *It was super awkward. It was the students on one side and the community on the other side and there was no interaction. Then there was me running back and forth saying bad jokes trying to figure out how it was going to work, so it was quite nerve-wracking but the common thing is that we were there to do a certain task and once we started doing that task it just blossomed. (Instructor 1 interview)*

The community builders took the lead and showed the students and instructors what to do. A huge sense of relief and appreciation for the guidance was experienced by the students.

> It was very nice to just begin doing everything that we had planned for so long. We needed the help of the community members to get us started, and they were great teachers and helpers the entire week. (Owen Portfolio)

> It felt nice to have them sweep in and save the day and be like here, this is how you need to do this and this is how we can set this up to work better and to have their different perspectives on problem-solving and things where they've actually worked through and built things properly, whereas we just kind of think that we know this is how things are going to work, so then they could really teach us in that way as well. (Kai interview)

> The community members did a significant amount of work but also provided a lot of space for us to do things, and they were so willing to teach us. Everyone was extremely respectful. It was a really good collaborative environment. They obviously had a lot more construction skills than myself so getting to learn from them about how to do certain things was really awesome. (Rebecca interview)

With the community members' expertise and guidance and everyone working together the first structural frame was assembled, hoisted and set into position on the concrete pad.

> When we got the first huge frame up, I think that was the first time anyone believed we could actually do it [build the project] even if we were weeks behind schedule. It made everyone feel more together and confident in the project. (Owen interview)

> *On day three of the site work, the first assembly was up in the air! It was a wonderful moment to see the project transformed from just an idea to an actual structure standing in the community. My heart was filled with pride. (Jrayanna portfolio)*

Students learned about specific construction tasks such as levelling a structure, "one thing I've never understood before is how you level things (laughs)" (Dana interview).

> *This is a process that I had never been a part of before and was happy to have the chance to help with. Because it is almost impossible to make the concrete pad level you need to level the actual columns. This process entailed figuring out which column was the lowest, and raising the others to the same height. (Dana portfolio)*

> *The entire structure needed to be raised and levelled according to the lowest point. This was accomplished using a series of chalk lines, string levels, and laser levelling. Blocking was used to temporarily raise each section to the appropriate height while fasteners were put into place to hold each column permanently. Afterwards, a team went around the structure and removed the blocking to create the appearance of a floating structure. (Liam portfolio)*

After a hard day's work in the evenings, the students had leisure time to enjoy the surrounding nature and to share life with the community members. This was an important space and time "where the relationships [between students and community members] really started to form" (Instructor 1).

> *I'm not sure if that was the original purpose of the course but it was fun it was kind of like a camping trip for students. We were bonding after work we got to know different*

> people and got to know each other more and had bonfires and went to swim and talk about life. (Jrayanna interview)
>
> The most enjoyable [part of the build week] honestly was our evening and getting to swim. We also hung out with those same members of the community that were helping us with the build, they would come and swim with us after a long workday and it was just a great experience. (Dana interview)
>
> There was one day where I went fishing with one of the Elders and Instructor 1 and then we caught 10 or 12 fish. (Rebecca interview)
>
> I just sat on the rocks and watched the lake and them fish. But that evening we got to hear a bit of the community members' life and vice versa. It felt good to be on the site and talk with the people there. Moments like that made it seem like everything [regarding the project] was [going to be] okay. (Owen interview)

The development of these relationships was demonstrated one morning, when the Elder, who was fishing with the university group, arrived on site with freshly fried fish for everyone.

> [The Elder] takes a student and I fishing right, he makes Cajian walleye filets fish and he comes back 10 o'clock in the morning the next day, after its cooked, with his tupperware container of Cajian walleye, that he is so proud of, for everybody at the building site to try. I think that's [symbolic of the communities giving nature] right there and that's how it is with everybody there. (Instructor 1 interview)
>
> We got to try fish from one of the local guys there it was the best fish I've ever had. (Owen interview)

The university students and community members continued to work together on building the feasting shelter. In the actively engaged hands-on process, the students learned about design tolerances and communication in a construction setting.

> *During construction, we realized that there were several issues with tolerances. The metal working on the plate fabrication for the anchor brackets and collar ties were made perfect "to a T" for either 1/2" or 3/4" sizing. It became very difficult to align the structure properly to adjust for any inaccuracies in lumber length, warp, and or angle. Attempts were made to widen the bolt holes by reaming since properly sized steel bits were bending and breaking as the holes were being widened. As a result of an accumulation of small inaccuracies, noticeable defects were found in the structure during erection. Thanks to the local community members, the imperfections were addressed and corrected by the end of the week. (Liam portfolio)*
>
> *The two main things we learned throughout the process were communication and tolerances. It is very important to communicate when changes are made to the whole team. It is also very important to build in tolerances when designing. We did not and that made the building process that much more difficult as everything needed to be exact. (Dana portfolio)*
>
> *It was a good chance to practice communication in a construction setting and learn some tricks of the trade from [the builders]. (Owen Portfolio)*

Progress was made on the common goal of building the feasting shelter designed for the community incorporating community needs and input. Relationships between the university students and the community members were also built during this process. One of the university students, grateful and moved by the generosity of the community members, took the initiative to

give them something in return. The student was involved in a non-profit sports organization and through that organization organized sports games for the youth in the community.

> *We ran that program, and it was like flag football and soccer and we ran it for one afternoon in SL40 FN during the build. (Rebecca interview)*

One day during lunch together there was a conversation between the instructor and two community members regarding the design of the seven columns representing the Seven Sacred Teachings. One of the community members, "mentioned that we have to remember that we all don't follow the traditional ways and that we have we practice others" (Instructor 1 interview).

> *I learned that you can't just go in thinking that everyone acknowledges certain beliefs that you have to be open and you have to be careful in how you create. (Instructor 1 interview)*

Making and learning from mistakes was a central activity in the build for both the students and instructors. Some students felt bad about the pre-fabrication mistakes they made, especially when the community builders had to re-do their work in order for the feasting shelter to stand. Other students realized that the mistakes they made were an important part of their learning process.

> *We [the students] definitely had a lot of problems with [the accuracy of the measurements], which I felt bad about, the [community builders had to] redo a lot of stuff themselves because we messed it up or didn't know how to actually do it. I think they knew that wasn't our fault but also like it be nice to know how to not do that again so we can all work together better. (Owen interview)*

> *This was a great opportunity to learn from people with years of experience and work right next to them. We [the students] made many mistakes, although all were great learning experiences. I enjoyed that we had the chance to make mistakes and try to figure things out, but when we needed help and advice it was there for us. (Dana portfolio)*

The activities that unfolded during the build week provided key learning moments for the students both concerning practical and technical skills and in terms of gaining relationship-building knowledge. Students identified the limits of their skills and knowledge and when and why they needed other people's expertise, help and guidance.

> I often joked that architectural features were just sprinkles or the cherry on top of the design, although, during the build week, I realized the same could be said for some structural features on the design … also known as over-engineering. No matter which perspective one is designing from whether it is architecture or engineering, there is a necessary balance and reciprocated relationship based on trust and respect for each other's knowledge basis. Diving into the other realm only made a stronger design with new/virgin eyes during each design iteration or construction hiccup. (Rebecca portfolio)

> *Throughout the design and build of the structure, we had interactions with community members, architects, engineers, and builders. We had the opportunity*

> *to design for a real client, this was my first time designing with actual guidelines from a real client. This is a great opportunity that taught me so much about how to interact with clients. (Dana portfolio)*

> Better understanding the way a project like this is assembled, should make designing projects in the future easier to understand, and work cohesively with builders. It was nice to spend so much time on the site and with members of the community. (Owen Portfolio)

> The product wouldn't have been nearly as good if we had to build the whole thing by ourselves without the community's help. They were a key factor in finishing the project even to the point where some of it had been unfinished when the course ended, and they finished up the little things that were left undone. (Kai interview)

> *I think that they [the students] learned, that through finding common ground, that working towards a goal together you can overcome any barriers that we mentally perceive.* [*The students and community members were] hugging when they [were] leaving at the end of the project. You felt the energy that there was this emotion had by the students and community and that a relationship was made. (Instructor 1 interview)*

There was a willingness amongst the entire group of university students, instructors and community members to work together on building the feasting shelter. They had respect and trust for each other and generously provided their professional expertise and guidance when needed. The community builders allowed students to gain experience in critical thinking, communication, problem-solving, and construction processes. This experience aided in the

students' perspective-making on how a design is translated into built form and what design aspects are important to consider from a practical and place based users standpoint. The community members played a key role in facilitating this learning for the students. The students gained clarity on their roles and responsibilities in the project by seeing the boundaries of their capabilities as engineering and architecture students. The students learned how to meet and work with other professionals at the boundaries of their skill and knowledge to create the feasting shelter. Figure 1 below is a photograph of the feasting shelter as it was being constructed during the build week. Success was realized because everyone involved had something necessary to contribute and valuable to gain. Furthermore, the build was approached in a way that allowed for genuine human-to-human interactions among the students and the community members which re-enforced respect for each other's role in the build and broader society. A genuine and deeper meaning was present in the work done, "I thought that was really cool that we weren't just coming in and plopping this thing down" (Dana interview). The final result of the constructed feasting shelter was built on a foundation of care for each other as peoples with unique backgrounds, expertise and identities shaped by the cultures and histories of their lived realities.

Figure 1: SL40 FN feasting shelter in construction photograph by Shawn Bailey (University of Manitoba, 2019)

Chapter 5: Discussion

The values and foundational principles of the design-build course, embodied and facilitated by the course instructors, Elders and SL40 FN community partners, shaped a teaching and learning environment that supported students' learning at three distinct boundaries of discipline, design and culture. Crossing an interfacing boundary requires encountering differences, navigating unfamiliar territory, and experiencing a lack of qualifications (Suchman, 1994). Therefore, the learning at each interface provided unique challenges and growth opportunities for the students. Participation in the design-build course helped shift students' paradigms around interdisciplinary work, design, and relations with Indigenous peoples. All three of these perspective-shifting areas required both an awareness of individual and professional identity, application of disciplinary skills and knowledge, and then negotiation and transformation of to cross and collaborate at the boundaries. Each area of perspective-shifting had a significant impact on students' learning. The final outcome of the course was pluralistic: the creation of a community feasting shelter and the building of respectful relationships. The underlying motivations guiding students' actions, as they navigated transdisciplinary spaces, was a desire to discover themselves, and to connect with who they are as a unique individuals with unique gifts, talents, and values, and how to contribute such to a greater purpose.

This chapter draws on the literature reviewed in Chapter 2 and additional works as needed to discuss the findings: the boundaries of engineering practice at the intersection of architecture practice in design work, through the translation of theoretical and conceptual design to its built form, and through the navigation of a new cultural landscape. Specifically, this chapter explores how engineering and architecture students encountered these boundaries and navigated them, what in the teaching and learning environment supported or did not support students' journeys, and what the students learned as a result. Lastly, this chapter discusses the

themes that acted as connecting factors, guiding principles and individual agency and values, present in students' learning between, across and beyond the boundaries, and the tensions and general observations, of initial stakeholder briefing, technical rigor and relationship-building and students background influences on paradigm shifts that were present in navigating these boundaries.

Engineering and Architecture Connection

Disciplinary-related interactions between engineering and architecture students began the second week of the course during design conception. Several of the engineering and architecture students had work experience with the other discipline, however working across disciplines in an academic setting was a new experience for all students. Despite some students having previous work experience initial interdisciplinary interactions presented barriers due to stereotypes, an inability to communicate effectively, and the dominant narrative of engineering education to prioritize the scientific method. As a result, the engineering students experienced resistance and frustration in their attempts to learn from the architectural approach to design.

The architecture conceptual design process, the *tools to facilitate learning*, used design charettes as the initial brainstorm for the design of the SL40 FN community feasting shelter. The architecture students were positioned to teach the engineering students how to sketch, draw and model initial design ideas. The engineering students entered into the conceptual design work perceiving architecture students to only care about aesthetics; "architects just care about a look, they don't care about safety, they don't really know how it works" (Student interview). In their research study, Keenahan & McCrum (2020) report the same stereotype engineering students initially had toward architecture students: "we don't just make things look pretty as they seemed to think" (p. 24). Another example of a limiting stereotype presented in the data regards engineering students' perceived creative abilities: "you have to remember that I am an engineer

and I have no creativity" (p. 4 Field Notes). The stereotypes the engineering students had limited their thinking and as a result, they experienced moments of resistance to engage with the architectural design process.

A cultural-historical explanation of why engineering students resisted learning the architectural process is that engineering culture prioritizes the scientific method so much so that other epistemologies are not valued (Godfrey & Parker, 2010). This is evident in that the engineering students could not rely on their disciplinary knowledge, such as free-body diagrams, as they tried to sketch and communicate their conceptual ideas. The engineering students' language of mathematics, binary numbers, stress, strain, and force flow diagrams could not be used to explore and create feeling, creativity, meaning and beauty within visual representations of the design. In Payne and Jesiek (2018) and this case study research it is evident that engineering students rely on their disciplinary education and background experience when they approach new problems and new concepts. Similarly, Greenhalgh-Spence et al. (2017) found engineering students' efforts of sense-making were influenced by their biases. When the problem is not grounded and framed in a way students are familiar with through their coursework or background experience, it is difficult for them to engage in the task at hand. Payne and Jesiek (2018) identified in their research study that engineering students also had difficulty understanding the non-technical dimensions of problem-framing. The barrier of engineering students not being able to rely on their disciplinary knowledge to engage with the architecture design process is reflective of the limits of engineering education in that it lacks pathways for scientific foundations to integrate with other disciplinary knowledge (Bordogna et al., 1995). This finding also indicates a need for scaffolding students' learning as they cross disciplinary boundaries.

The SL40 FN Design Build course created pathways for students to find connections between their discipline foundations. Through, side by side active participation in the design process together, the engineering and architecture students began to learn how each discipline thinks, how they approach creativity and problem-solving, what tools they use and why. More opportunities existed to directly apply engineering skills of statics and dynamics mechanical physics, and project management. Through continued conversation and negotiation with architectural considerations and by seeing the final drawings and final 3D models of the design, the engineering students began to see legitimacy in the architectural process. At the end of the course, the students moved beyond viewing each other through stereotypes, recognizing that "after collaborating and getting a closer look at the architects in this class, I realized how narrow my view was" (Student portfolio). Another student realized that actually "engineers and architects get along" (Student portfolio). This aligns with Edmunds et al. (2013) who similarly found that having students work with people from other disciplines on shared projects can break stereotypes and foster collaboration and integration of practices. Essential to collaboration is that students in this case study realized how each discipline had an essential role to play in the project and that they depend on each other to succeed. Sustained interaction, collaboration, and co-creations, between the engineering and architecture students influenced them to be curious and receptive to each other's perspectives and contributions to the design. As one engineering student mentioned, "the hybridity of the class opened up a brand-new world to me…understanding another profession advantages me in not only building a relationship with architecture professionals but also collaborations with other professionals" (Student portfolio). Another student acknowledged that, "going into another design-build would be challenging without engineering student involvement" (Student portfolio). Payne & Jesiek (2018), Keenahan and McCrum (2020), Edmunds et al. (2013) and Greenhalgh-Spencer et al. (2017) all report a shift in

students' perspectives in terms of how students view and engage with different disciplinary perspectives and processes in design work after working alongside students from other disciplines.

The SL40 FN design-build course allowed students to develop their interdisciplinary communication skills of listening, hearing different perspectives, and valuing information shared with them from different epistemological origins to collaborate in the space between disciplinary foundations and paradigms. The following student quote demonstrates this:

> The communication part is really important, I'd even say it's 50-50, 50% we do the design correctly, accurately and safely but 50% is we communicate with people. I want to have an open mind for these people from other disciplines, you need to understand what they're thinking so that we can cooperate with them better. (Student interview)

In addition to communication skills and expanded student perspectives, there were signs of students developing their mental adaptability in the interdisciplinary design work. The students in the case study comment on learning "how to adapt ourselves to mesh well with the others" and learning how to "balance between aesthetic and construction practicality" (Student interview). This understanding aligns with Keenahan and McCrum (2020) who found that the students in their course learned the "importance of being flexible in their thinking" (p. 22).

Design Actualization

The findings from this research align with the literature reviewed in Chapter 2: active participation in a transdisciplinary course/program employing project/problem-based learning brings students past the limits of their disciplinary design perspectives; it supports increased clarity on their role in a joint project and how to work with diverse stakeholders on a common goal (Riley et al., 2006; Payne & Jesiek, 2018; Guyotte et al., 2014; Edmunds et al., 2013). Approaches in the teaching and learning environment to facilitate students' learning in this way

include stakeholder interactions, out of classroom activities, engagement in extra-disciplinary tasks, navigating uncertainty, and instructors learning with the students. This research adds to the reviewed literature on the importance of making and learning from mistakes as a method for helping students learn about design actualization.

The various stakeholder interactions encouraged off-campus activities and engagement in extra-disciplinary tasks. In the SL40 FN Design Build course, Elder Meade and Elder Carl Stone, prefabrication and construction professionals, Sustainability-in-Action Facility (SiAF) lab technicians, and the SL40 FN community builders all helped the students translate their design idea into a built form. Prefabrication was facilitated on campus at a workshop. Professional builders external to the university were brought to the SiAF to provide students with guidance. The course instructors allowed students to make mistakes, encouraging them to problem-solve on the go. The problem-solving required collaboration between the engineers, architects and project stakeholders. The process of students making a mistake, realizing the mistake and then finding a solution also required the students and the instructors to work through any uncertainty on how to move forward. For some of the students making mistakes, or realizing that their designs didn't work as planned, had an emotional impact. As several students commented:

> [The design] didn't end up working as originally designed. That was heartbreaking because it was such a fun idea. (Student interview)

> We [the students] definitely had a lot of problems with [the accuracy of the measurements], which I felt bad about, the [community builders had to] redo a lot of stuff themselves because we messed it up or didn't know how to actually do it. (Student interview)

Moving through failure can be an emotionally charged endeavour and is a significant process for building humility. In the case of this research, students began to realize that it's impossible to know all the answers. They were brought past the limits of their capabilities as they engaged in extra-disciplinary tasks and were guided to learn from professionals on those tasks. They began to see how their work impacted, or was dependant on the work of the professional builders. An example of this from the SL40 FN Design Build, during the build week, when the architecture and engineering group was on site for a couple of days without the community builders and were stuck; they had challenges assembling their pre-fabricated components. When the community members arrived and showed them what to do there was a huge sense of relief. It seems that because the students sat for an extended period of time with the uncertainty and failure resulting from engaging in tasks beyond their disciplinary knowledge, they appreciated the contribution and guidance of the community builders even more. Having the humility to be a beginner in new areas of practice, and to learn from mistakes signals a shift in isolated disciplinary thinking towards a true understanding of how one's work impacts another's. In other words, the students learned how their design work exists in a broader and interconnected environment where they are influenced by the contributions from other people and knowledges.

> Hands on experience and real-life applications; that's the line that separates engineering education and practice, and we think – I think – we crossed that line. This [design build course] helped a lot, I think [the students saw how they] can have an impact on the client and [their] life, in this case being the [SL40 FN] community. I think understanding and getting to know the community is as big as the hands-on experience process. (Instructor interview)

Having architecture and engineering students engage in building tasks brings them outside of their disciplinary practice, helping them see how their disciplinary practice can

burdens construction work and the end users. Several students believed that the design was over-engineered or overly detailed to the point that the planned design requirements became a hindrance to construction efficiency and took time away from community interactions. Because of this, students realized their design mistakes regarding safety requirements, harmony with the landscape, and design tolerances and measurements. They also learned that different perspectives and knowledges are required for project success, which is also reflected in students learning from the studies of Riley et al., 2006; Greenhalgh-Spencer et al., 2017; Keenahan & McCrum, 2020; Payne & Jesiek, 2018 and Guyotte et al., 2014.

Student openness and desire to critically reflect on disciplinary assumptions are key to learning from stakeholder perspectives. Payne and Jesiek (2018) briefly report observed students' openness to hear different perspectives and an openness to change their own perspectives. Edmunds et al., (2013) discuss how the engineers in their transdisciplinary community build project had to 'open up' their disciplinary assumptions of energy optimization and efficiency in order to work with the realities faced in the PPN community. Riley et al. (2006) report that the transdisciplinary teaching and learning environments in their studies opened students' perspectives, with students becoming more "aware of realities and worldviews different from their own, influencing them to think critically about their own assumptions" (p. 156). Greenhalgh-Spencer et al. (2017), conclude from their research that moments of being 'pulled up short', or suddenly understanding how one's prior perspective was inaccurate, partial or wrong, are created in the teaching and learning environment when there are conversations and openness in expressing and learning different perspectives. It is evident that the student participants in this research study were open to learning from the different stakeholders in the course and had genuine curiosity, kindness, and valued the experiential and extra-disciplinary learning environments promoted in the design-build course. The SL40 FN Design Build was not a

mandatory course and therefore gave students the autonomy to self-select the course. Students selecting the course based on how the course description aligned with their values and interests likely contributed to higher degrees of learning in the course. As well the engineering students were supported by their home departments who granted them permission to take the course as a technical elective.

In the absence of a common language to bridge the unique and different organization and the needs of people with adjacent realities (engineering, architecture, construction, community, nature), relationships with the people based on genuine care and reciprocity are important. In finding a common language and a common project goal, Edmunds et al. (2013) "emphasize the importance of balanced multilogue" in that each stakeholder's perspective is equally expressed and acknowledged and that the "learning process between professional and non-professionals is mutual" (p. 812). If there is a genuine desire to learn from the people in adjacent realities, and these people welcome you into their practices, taking off the engineer or architecture hat and being open to receiving new perspectives and teachings ultimately influences engineering and architecture design decisions that support the integration of diverse knowledge and co-creation.

From the perspective of engineering education, this course is fundamentally different from the standard curriculum in that it not only exercises in-depth disciplinary thinking it also supports the development of what Bordonga et al. (1995) identify to be lateral thinking and experiential learning. In alignment with Bordonga et al. (1995, p.195), criteria for holistic engineering education is present in the SL40 FN Design Build course in that engineering students "think across a variety of disciplines as well as in terms of disciplinary depth, couple experience with abstract descriptions, develop ideas and nurture and implement them, formulate problems and solve them, act both as a team member and independently, recognize, contribute to, and enjoy the relationship of engineering to the social, economic, political, environmental,

context" of the work. From the architecture education perspective, this course aligns with land-based paradigms developed by Bailey et al. (2022) that help architecture education evolve away from a colonial framework separating Indigenous and western worldviews and knowledges to create "mutually beneficial and synergetic relationships" in design work. The land-based paradigms provide space for students to connect with people and places, use their intuition, and develop listening, visions, and modalities of reciprocity to "share a good story" (Bailey et al., 2022). The goal of teaching and learning from these paradigms is "to create a sense of awareness in the individual, making them available to the teachings of the land and community, to promote creativity, and to remind them to always ask, *how am I giving back*?" (Bailey et al., 2022). The site visit and interactions with the community members in the SL40 FN Design Build helped the students understand how the design and built structure would "leave its mark" in the community (Student interview). The students in the course refined their understanding on how designs can lead to "sensitive and meaningful architecture that provides for the people", as opposed to designs that are "intrusive and destructive like architecture tends to be" (Student interview). Overall it was important for the students to learn from and connect with the people of SL40 First Nation so that they could contribute to a design that was meaningful to them. The following quote is provide as supporting evidence.

> It was nice to see, for me, the importance that architecture and engineering has in community. So I think if [education is] done to sort of push the constraints of how it is traditionally done to be more collaborative and be more empowering; to be more capacity building and ways of including community; I think that is a really beautiful thing. So I think doing projects that seem to go beyond the student, it's not just for them, it goes beyond [which] is really critical. (Instructor interview)

This shift in engineering and architecture design paradigms fostered by the SL40 FN Design Build aligns with what Edmunds et al. (2013, p. 812) state as a "crucial step in breaking the historic pattern" of western approaches to design that essentially capture a community view, without contextual place-based grounding and lived understanding, and then interpret that view from a place of siloed professional expertise. The stakeholder collaboration in the SL40 FN Design Build resonates with Edmunds et al. (2013) findings in which the stakeholders in their transdisciplinary community-based project "situated their experience more or less openly, making everyone's knowledge available for evaluation, interpretation, and appropriation (with safeguards in place) or critique" (p. 821). This creates pathways of knowledge exchange between disciplines and extra-disciplinary knowledge that promote co-creation and mutual benefit. This is reflected by one instructor:

> Well in terms of reconciliation, I think that it was probably a very impactful project. I really think it was true reconciliation because there were moments where, I think, that everyone was sort of on this equal ground, that the making [of the joint project] allowed everybody to do [something], which was quite nice. You watch the [community] youth interact with the students, and they were quite shy at first and hesitant and I think they also learned that they didn't have to be. I have lots of pictures of them [the community youth] holding the nail for the hammer [of the university students]. I think it [the design build project] showed everyone [involved that] we're just people, which was really nice. (Instructor interview)

Navigating New Cultural Territory

Unique to the course is that it provided space for students to engage in meaningful interactions and conversations with the course's Indigenous partners, to experience their lives and cultures from their teachers and on their lands. This provided embodied experiential and

relational learning opportunities for understanding how the histories and current realities of the SL40 FN community members are connected to engineering and architecture design and build work. The course's Indigenous partners subtly brought students to recognize the pre-existing tensions within their society that are barriers to having healthy relationships with Indigenous peoples. As Goodchild (2021) describes, these tensions include heightened paternalism, need for power and control, disconnection from the body and nature that enables seeing, feeling and listening deeply, lack of understanding of who one is and where they come from, and disregard for feminine principles. Although most of the students were not fully conscious of these tensions they were influenced and guided by the Indigenous partners, course instructors, places of teaching and learning and learning activities to learn in ways that countered these tensions. This was a continuous process throughout the course and will be discussed throughout this section.

The design-build course introduction on day one, by the course instructors, brought students' attention to the Winnipeg Aqueduct. The majority of the students in the course were not aware of the negative impact that the Winnipeg aqueduct had on SL40 FN. Most notably the communities forced relocation, safe and reliable transportation in and out of the community, and that it destroyed the community's clean drinking water. However, the majority of the students were quick to realize the inequality the infrastructure caused, signalling the care and empathy the students had. Beyond this students' initial responses varied. Several students wanted to help the community by designing and building a structure where everybody was welcomed. Other students wanted to learn how to be better engineers and architects working with Indigenous peoples. There is a difference between these two initial responses. The first response is one of non-Indigenous university students wanting to help fix the problem of injustice which requires problem definition. Who defines the problem of injustice? Is there a difference between how a non-Indigenous university student understands the problem and how Indigenous community

members understand the problem? What happens when the problem is defined without the community? Simpson (2016) problematizes the desire of wanting to help when it comes from people rooted in the paradigms that caused the harm in the first place. Simpson (2016) states: “as Indigenous communities, we often have social justice groups wanting to help, but they fall into a white saviour complex by centering whiteness or being unwilling to join in the ways that Indigenous peoples are already organizing at the community level” (p. 20). This type of behaviour, conscious or not, perpetuates the need for power and control. The second type of student response is more open to meeting the community members where they are and is more supportive with what Simpson (2016) calls for Indigenous resurgence. This type of response embodies a humility acknowledging the principles and mechanisms of white supremacy, capitalism and heteropatriarchy rooted in western institutional paradigms that need to be addressed. In other words, colonial ideology, policy and culture are at the foundation of Canadian scholarship (Kovach, 2021a) and cannot be ignored. This mentality is not always consciously in the minds of people but is inherent to the social, political and economic organizations and processes that influence what we as people do, and as one student in the course acknowledged as “the key reasonings for why many of the challenges Indigenous communities face” exist (Student interview), reasons decided upon that set the direction for engineering and architecture work, as showcased in the history of the Winnipeg Aqueduct design and build in Chapter 1. The course did not bring students this deep into the complexities of colonization, the role engineering and architecture play in ongoing colonialism, and the legacy of hierarchical relationships of power between Indigenous Nations and the Canadian government, however it did provide students with an opportunity to challenge this legacy and move forward in more respectful ways based on the values and guiding principles of the course.

The on-campus Elders played a significant role in influencing students' perspectives on concepts completely new to them and not traditionally supported by the cultural and historical narratives of Canadian higher education. The Elders introduced the students to cultural teachings and provided them with practical information on how to approach design work with Indigenous peoples. The students respected the Elders and were open to listening and observing what they shared. Furthermore, part of the teachings were provided in Migizi Agamik, the Indigenous Student Center on-campus, which was designed and built with explicit Indigenous cultural dimensions. Educating in a space that reflected and embodied the cultural teachings of the Elders may have supported students' respect for the teachings they were receiving. Some of the students were influenced by the Indigenous perspective and environment to think differently about design work. As one student stated: “the Elders’ taught us to think about things a little differently than how we would usually do and that made me give things a little bit more thought” (Student interview). The most notable expanded perspective present in the student's responses revolved around the philosophy of design's connection to the land. This is evident in the following student’s response to the Elders' teachings, “it was definitely something we hadn't really touched on that much [in other course work] this kind of connection to the land” (Student interview). Another student commented on how they were influenced to think deeper on how to not “be so destructive to the environment in our ways of building” (Student interview).

Gaining clarity on one’s positionality was another learning outcome experienced by the students from the Elders’ teachings in the course. The Elders helped the students reflect on their individual and collective identity by exploring their positionality as non-Indigenous university students entering into an Indigenous community. The majority of the students had not been to a First Nations reservation before. Due to the legacy of destructive relationships between Indigenous and non-Indigenous peoples, and with currently existing power imbalances, it was

difficult and uncomfortable for some students to acknowledge their privileges and make sense of their role in entering the community. Some of the students who identify as white men recognized that they belonged to a group of people that historically caused harm to the SL40 FN community. They questioned how they could be better and not perpetuate white superiority. Other students recognized cultural differences between their backgrounds and the SL40 FN community and because of that wanted to make sure they were prepared enough to not offend the community or cause any harm to the community members, especially when knowing about the harmful actions the community endured from outsiders in the past. One of the students wanted to know how they could feel comfortable going into the SL40 FN community. Elder Carl Stone helped address paternalistic attitudes and ontological boundaries present in the minds of some students when he said; "it's not about you, the people [community members] have to feel comfortable with you" (Field Notes). The students sense-making of their positionality was directly related to awareness of their ontological origins and how they navigated knowledge beyond their ontological bounds. Hunt (2016) suggests that the process for a non-Indigenous person desiring to engage with Indigenous people and their ways of knowing requires being uncomfortable and "stepping beyond the position of 'expert' in order to also be a witness or listener" (p. 31). The students genuinely desired to have a relationship with the SL40 FN community, however in order to advance in that direction they had to face and overcome their fears and discomfort in navigating a knowledge basis beyond the boundaries legitimizing their reality.

A significant factor that influenced students to learn the reality of the community members of SL40 FN was that the teaching and learning environment, in part, was on community land and taught by community members. Some of the students had moments of revelation when interacting with the community members and listening to their stories on site in Shoal Lake 40 First Nation. For example, one student was expecting the community to look like

a First Nations village from their high school history textbooks and was shocked to find out how modern it was. Another student did not realize the inequality the Winnipeg Aqueduct caused until they were in Shoal Lake 40 First Nation and saw for themselves how the community was turned into an artificial island and directly heard about the negative impact from the community members.

Students experienced a drum ceremony led by a community knowledge holder who sang a prayer song using a handmade hand drum. The students didn't describe this experience in detail, but all of them mentioned it, specifically how it was "very special", "powerful" and "touching" (Student interviews). The community offered their songs and ceremonies to connect with the students in a way that students were not taught to connect with other people in their schooling or in ways the English language and rational thought cannot connect people who hold alternative worldviews. When worldviews are very different, for example, when values placed on time, money, land, and relationships contradict, it is difficult to find ways to connect as diverse people and "relate to each other in understanding and compassionate ways" (Goodchild, 2021, p. 80). Foot (2014) states that the tools to facilitate learning in the activity system are material or conceptual; the approach the community knowledge holder used had emotional and spiritual dimensions. Engaging students in emotional and spiritual dimensions are important for them to engage with Indigenous ways of being and knowledges and thus the people who embody this way of life. As Hunt (2016, p. 31) shares, Indigenous knowledge is "relational, alive, emergent" so any attempt to categorize or fix its meaning as we engage with it puts us at risk of missing something.

The powwow was also a significant approach to facilitating students' learning that furthered emotional and spiritual modalities of teaching and learning. As Hunt (2014) explains there are ontological differences between "intellectual and lived expressions of Indigeneity" (p.

30). Participation in cultural ceremonies, and the in-person experience of song, music and kinship are subtle but powerful entry points for the students to genuinely learn from Indigenous-centered and place-based knowledges existing beyond intellectual realms. This is supported by a student's comment that "experiencing a ceremony is the best way to learn about a culture you are not familiar with" (Student interview). By participating in her first potlatch ceremony in her community Hunt (2014) learned about her community's knowledge in ways "no guidebooks or PowerPoints, no essay or instructional video could have" (p. 30). Participation in the powwow was an approach to facilitate students' learning about the communities' ontologies and structures of knowledge. It was a type of teaching and learning embodied by the students, with the sounds they were hearing, the fresh air they were breathing, the movements of their dancing feet, feelings of connection and lived community values, and the sights of the regalia and communal orchestration of the event.

Furthermore, the community members were very welcoming to the university group. They invited them to participate in their ceremonies and shared personal stories of their lived experiences. The students spoke about stories shared with them about the community members experiences in Residential Schools. This is a vulnerable emotional sharing that touched some of the students. The community members who openly spoke about their suffering, in a safe environment, moved some of the students. These students, by finding a connection to the community members through their own experiences with suffering, empathized with the community members and found a way to relate to the impact of, for example, residential schools.

> I feel like the course was teaching the students that you need to interact with the people you're designing for one, and that we're there to learn from Indigenous people so having everyday conversations and them telling us their story is super important. (Student interview)

It was essential for students to be in the community, genuinely engage with the community, and be open to the new environment and culture for them to have paradigm shifts in how they relate to and work with Indigenous peoples. Through the community welcoming, sharing and teaching the students, the students were able to connect with the peoples and lands of SL40 FN in a way where they became to value the community members' lived reality. In contrast to this active cross-cultural learning is in classroom learning of a different culture, which has limits on preparing relationship building abilities in students. One student said,

> You can drill home the facts as many times as you want but if you don't connect with it [the facts] you're not really going to place value on it. (Student interview)

The students felt accepted for who they were as outsiders to the community. A real and genuine sharing of emotion encouraged students to learn not only with their brains but also their hearts. Ultimately, the emotional connection established between the students and the community members provided the students with a deeper meaning for the project, a desire to want to learn more from the community members, and motivation to overcome separating barriers.

The relationship that formed and grew between the students and community partners helped the students affirm the importance and value of relationships in design work. This is evident in the following student quote:

> The opportunity to actually talk with the community and actually work with them is a lot more valuable than just almost like pretending that everything's gonna work perfectly and thinking that the community is going to accept these things that we imagine and think about. With the [SL40 FN Design Build] course where we can actually go into the community and talk with them and have them be an active member in the design process makes it a lot more real and it is a really valuable experience in contrast to just the typical kind of teaching that we would usually get. (Student interview)

The students also found reassurance from their relationship with the community members that everything was going to be okay in times of stress and uncertainty. The forming of relationships helped one student be "more present and thoughtful" in the tasks at hand (Student interview). This is significant as it provided perspective and balance to the felt time crunches and helped students reflect on how western rules of budgets and schedules drive the decisions they make and the work they do.

There was space in the course structure to be organic, to have room for spontaneity so the students didn't always know what was coming next or what to expect. This was especially important working with a First Nations community because the typical western ways of following plans and budgets keeps people engrained in their own agendas and prevents more authentic or genuine interactions from happening. As one instructor explained:

> Especially working in community with a knowledge keeper …it just gives proof that there is this sort of hidden wisdom beyond us [University academics] and sometimes when you're more open, and you allow these things [to] happen how they're meant to be, so I don't know it's nice it's a lot lighter way because I find in engineering and architecture it is always about control, control, control or we are controlling this we are controlling that, so I think it's like allowing some flexibility into the way we think. (Instructor 1 interview)

Was this explicitly communicated to the students? It does not seem so. We see some students who experienced frustration, uncertainty, and confusion as the course led them out of their normal or conditioned ways of thinking and being. This is where group and individual reflection could have helped the students process and make sense of what they were experiencing.

Bordogna et al. (1995) state that learning to be in mental states of ambiguity and perceived chaos is a component of holistic post-secondary education. To the new experiences of

university students, these contextual learnings were seen as loosely or indirectly connected to the design and build of the feasting shelter. They had to be able to build these connections to the project without a rational explanation. This challenged students to shift their paradigms. The following research participant quotes are provided as strong evidence supporting paradigm shifts in both engineering and architecture students' mentalities towards working partnerships with Indigenous communities as either engineers or architects.

> Looking at history and looking exactly at the Winnipeg Aqueduct the problem with engineering is that we all consider ourselves separate '*your community' 'my community' 'my land'* and *'your land'*. This course gave me the opportunity to acknowledge that this is all of our responsibilities. I was born and raised on Shoal Lake water, I'm literally made of Shoal Lake water. We are taking their resources. We have to acknowledge our place our position and our responsibility. (Student interview)

> From day one we told the students this [design build project] is not something that we're imposing on the community; we're going to the community and listening to them and we're asking what is it that they want us to do for them and maybe they would say nothing. (Instructor Interview)

> I can be told that these things have happened, and I can learn about them, and I am aware of them, but I don't understand how that impacts the community… I can sit in a formal classroom, and you can tell me all these facts and I will learn them, but I won't exactly take that away and then attach that to other things that I'm doing. I don't think that comes naturally unless you place some type of value on it yourself. So I think that's a basis for any type of engineer design, you place value on different types of criteria and constraints

and different requirements within the project; everything is value-based from a budgeting standpoint as well, so then how do you place a value on Traditional Knowledge and things like that. So just understanding it [Traditional Knowledge] and learning from it makes my personal philosophy value it. So hopefully when I go back into these community projects and things like that, because I learned it, I also have value for what I've learned and a better understanding of how it impacts them that I can make better decisions to solve certain issues through my design. (Student interview)

I see the value and the importance on Traditional Knowledge versus someone just telling me that Traditional Knowledge has impact for these reasons. Because I don't think that you can learn Traditional Knowledge at all from a textbook. Like it has value in the community because it's passed on knowledge… I think my first opinion honestly was that I sort of frowned upon it. Because Traditional Knowledge to me was like, okay, well how do they know better about a caribou route or something about hunting grounds and everything from all these wildlife experts and everyone that goes into the field and conducts all these scientific surveys and analysis? And that was because I didn't have any value for it [Traditional Knowledge]. I didn't appreciate it for what it was. But then being in the community and learning from them, seeing how it impacts them in their daily life; not only that it has importance and it'll help out a project when you incorporate Traditional Knowledge but then seeing how they actually would use that knowledge to better their lives and the future. (Student interview)

I'm feeling inspired by the people who are around me because they're accepting of me and the type of individual I am. So what is this big issue around institutional racism and

> systemic racism? Why do we judge Indigenous individuals for certain types of decisions? Like what is so different between us and them? (Student interview)

Goldfinch and Kennedy (2013) remind us that the relationship with an Indigenous community is people and place-based. An in-person relationship, on Indigenous lands, with healthy discourse is the main mechanism for understanding the perspectives and structures of the community as there is no pan-Indigenous references for the language, culture, political, spiritual and economic systems of knowing from community to community. Students in the course went through a relationship-building process outlined by the University of Manitoba Community Engaged Learning (2021) Pathway for Indigenous Community Engagement. The students did "the work before the work" by receiving cultural teachings and perspectives from the Elders on campus and spending time in the community getting to know the community, so that they could form a partnership built on trust and directed to meet community needs. Collaboration and humility were evident in the students during the build week when they worked with the community builders and learned more about their roles as engineers and architects in the community build. At the end of the course the students left the community with a sense of gratitude and shared emotion for the human-to-human connection developed and the final co-created structure.

Guiding Principles and Values

A theme underlying students' motivations, as they navigated the various boundaries encompassing multi-present paradigms, are guiding principles and values. The literature on transdisciplinary approaches in higher education reviewed in Chapter 2 highlights that the course/program structure is influenced by the instructors' and non-academic partners' values, which establish the guiding principles for the teaching and learning environment (Leung, 2020; Jesiek et al.,2018; Gulikers and Oonk, 2019). Transdisciplinary approaches are also situated in a historical-cultural context of people and place. The people initiating the interdisciplinary,

interprofessional and intercultural partnerships have an awareness of their own history and culture and how it bumps against their neighbours, who might experience a differing history and culture. In the SL40 FN Design Build, instructors saw that successful problem-solving and design depend on the relationship between the problem and its environmental (people and place) contextualization (Wolff, 2017). The instructors' desire to form partnerships outside of their domain comes from a desire to improve their domain's practices internally and at the interface with their neighbours, so that disciplinary knowledge is applied in ways that create equitable positive change for everyone involved and establish harmonious continuity at boarders of difference.

One of the principles that the instructors had was to promote respectful relationships with the course's Indigenous partners. Instead of abiding by the rules and norms of a single system, the focus was on a mutually agreed upon set of principles (Leung, 2020). Ermine (2007), a Cree scholar, reminds us that reconciliation between Indigenous and western peoples requires us to reconcile our worldviews. The concept of *ethical space* proposes a framework for Indigenous and western peoples to meet and start from when engaging in work, and is directed towards reconciliation. Ethical space is a meeting place for contrasting worldviews and perspectives to exist with each other and co-exist in harmony: A meeting place where Indigenous and western people both affirm "human diversity created by philosophical and cultural differences" (Ermine, 2007, p. 202). The people in ethical space put their allegiances aside and give space to detach from what they know reality to be. The intercultural dialogue in ethical space,

> might seem overwhelming because it will involve and encompass issues like language, distinct histories, knowledge traditions, values, interests, and social, economic and political realities and how these impact and influence an agreement to interact (Ermine, 2007, p. 202).

Individual Agency and Values

Another theme noticed underlying students' motivations throughout the course, is that they had a deeper need to develop their sense of individual agency and connect with their individual values, gaining clarity on what it was that really mattered to them. For several of the students, the people in the course mattered; they wanted to learn from people with different backgrounds, experiences and cultures, and work with them to create something new. Meaning was also found in doing work that was directly connected to the real world, with the potential to make a positive impact on other people's lives. The following student quotes are provided to demonstrate this.

> I often question my position within the engineering field in Canada. Do I belong here, am I getting respected because of my work or because I am the minority that is required in the office to check the administrative boxes? Do my morals align with modern-day engineering and sustainability? During the time spent working on this project, I never questioned my abilities and never felt as though I was being demeaned in any way. I felt respected and empowered, something that does not occur often within western culture. This class has helped me to see my place and exactly where I should and want to be within the engineering world. (Student portfolio)

> I hear a lot of students reflecting back on their types of experiences from a learning and education standpoint, but not typically from an excitement and passion about what they're learning about. Since this course was more structured on the experience and working together collaboratively with other individuals, I reflect back on it with positive emotions and positive outcomes versus typical courses that I take, which I would just say are positive outcomes and not so many positive emotions. My capstone course was project-

> based. I had a good time in the course, I learned a lot, but it was stressful, like just *stressful*, and that doesn't exactly reflect positively back; and I can't really recall many things that I learned. That was only a year and two months ago that I finished that versus reflecting back on the SL40 FN Design Build course: I had all these positive ideas and emotions that I could remember. (Student interview)

> We were able to pull together the practical limitations of building design with the need to create an artistic structure that met the client's needs. We not only accomplished this, but we also built a structure with meaning and purpose. To me, feeling connected to the project and sharing in the work with the community was the best takeaway I've received during my undergraduate degree. (Student portfolio)

Tensions, Observations and Recommendations

Tensions present in the research findings include barriers to initially understating the other's disciplinary perspectives and balancing technical demand with integration of community knowledge. Although all the student participants in this research experienced paradigm shifts, the degree and area of shift were not equally observed.

Initial stakeholder briefing

In this case study, the students were introduced to the Shoal Lake 40 First Nation community by the instructors and lectures before visiting the community members. Furthermore, they received cultural teachings from Elders on Campus. This work before the work is the first step to meaningful community engagement (Community Engaged Learning, 2021) and helped prepare students to show up with an open mind and respectful conduct in Shoal Lake 40 First Nation. Contrarily, the engineering and architecture students were not briefed on the other discipline before beginning their design work together. This could be another reason why some

of the engineering students were initially resistant to learning from the architecture students. A recommendation from this case study research, also identified by the research participants, is to have an introduction to the engineering mindset and practice and the architecture mindset and practice with the goal of helping the students from the respective disciplines overcome communication barriers. This aligns with Payne and Jesiek (2018), who recommend transdisciplinary design courses to have exercises at the beginning of the course to acquaint students with the realities of the other disciplines and stakeholders around the shared problem before engaging in the joint work.

Technical rigour and relationship-building

The design process was largely rooted in engineering and architecture disciplinary knowledge and practice and contained within academic walls. The high degree of disciplinary technicality took away time and space from learning and integrating the local Indigenous cultural knowledge and practices. The dissolving of stereotypes and integration of knowledge between disciplines happened quicker for students than it did with Indigenous ways of being knowing. This could possibly be because differences in worldviews and across cultures are larger boundaries to cross then when crossing the boundaries between engineering and architecture disciplines. As well, the students had much more time to interact with each other throughout the course; they did everything together from day one of design to the final build. Drawing on the work of Lucy Suchman (1994), she recommends that to develop systems or technology with integrity, the development must be grounded in relationships to the specific settings and people using it. It isn't easy to foster grounding end-user relationships when technical development happens within institutions that carefully guide practices and arrangements in precise ways (Suchman, 1994). Engineering and architecture programs are rigidly structured with pre-defined learning outcomes specific to prioritized industry needs. The rigidity created by strongly pre-

defined learning outcomes creates challenges for professors and leaders in having two-way relationships with “unprioritized” community members receiving engineering (Suchman, 1994) and or architecture services. Although the design-build course had principles and a teaching and learning environment that valued community involvement, the existing engineering and architecture cultural norms created tension in fulfilling the course and build requirements, and at times over-powered the course principles. This is because the strongly defined and fortified structures engineers and architects operate in have minimal permeability for differing paradigms (Suchman, 1994). Paradigm permeability was essential for the success of the SL40 FN Design Build course. The findings from this research support the importance of space for ambiguity in order to learn at boundaries of practice or knowledge, and to effectively cross them (Leung, 2020). The research participants, both students and instructors, identified a smaller project with more community involvement, specifically at the design stage, and then more interactions throughout, for future versions of the course to have a better chance of learning from and integrating community knowledge. This aligns with Payne and Jesiek (2018), who found that the course stakeholders influenced the students' extra-disciplinary learning more so than the course instructors. They claim prolonged, consistent and direct contact with the project stakeholders is essential to support students' extra-disciplinary learning. The following quotes from this research are provided as argument for balancing technical demand and community engagement.

> I think a smaller project would allow for more time for community engagement which I think was actually lacking quite a bit… that design [of the feasting shelter] really was from the students and with some instruction from the community, some discussion. (Instructor interview)

> It slowed things down [when Elder Meade came to visit during the prefabrication]; we could have a more balanced and calm conversation about things. It's easy to get caught up in things, these courses are very hectic and there's a lot of people trying to do a lot of different things at the same time. Elder Meade brought perspective back into what we are doing and why [we are doing it]. There should be more of this for this to be a better project in the future or next time around. (Student interview)

When creating more space for learning and integration of Indigenous knowledges, there must also be an openness to diverse epistemologies. It is important for differing beliefs to be present, and to have students reflect on the role of those beliefs, and consider how to work with others with different beliefs. This claim is supported by Edmunds et al. (2013) who caution those within academia to be aware of what types of epistemologies and beliefs are favoured over others within the academy.

Further recommendations for future work provided by participant responses and which align with the Pathway for Indigenous Community Engagement Framework (Community Engaged Learning, 2021) include more time for self-reflection and an organized event to close the partnership. Space and time to regularly engage in self-reflection with guidance and resources throughout the course could help students gain clarity on how and why their perspectives and identities are shifting and the meaning of this. A closing ceremony or event with the community could be beneficial for exchanging gratitude, affirming the good work done, and discussing conflict or lessons learned that would be helpful for future engagements. As one instructor and one student realized:

> I thought maybe we needed a closing ceremony kind of thing just sit down and talk about our experiences and build up some friendship. (Instructor 2 interview)

> There should be some sort of survey or conversation at the end [of the course] to reflect on things so that they can be reconciled and acted on in the future. We could've done a sharing circle with the community or without the community. (Student interview)

Collective discussion and reflection are mechanisms to ensure dominant hegemonies do not overpower a newly created partnership. Hunt (2016, p. 31) shares that engagement with Indigenous peoples and their knowledges requires a "shift in disciplinary ontologies and epistemologies", which requires ongoing "work at individual and disciplinary levels". Riley et al. (2006) share their engineering and architecture course which is very similar to the SL40 FN Design Build course and report having their students write individual and collective reflections. Dr. Little Bear, when teaching to students, non-Indigenous and Indigenous tells stories from both a western point of view and then an Indigenous point of view. He recognizes that students must have something to relate to, "to be able to transcend the boundaries." (Henderson & Little Bear, 2021, p. 208). Part of Dr. Little Bear's approach to this is having, "people look at the paradigms" and that these are just, "interpretational tools for reality structuring" (Henderson & Little Bear, 2021, p. 208) not reality in its totality. Through engagement with the Indigenous course partners, the students could step outside of their disciplinary and western-centric paradigms, onto different cultural territory and reflect back on the realities they came from.

Paradigm shifts and the influence of students' backgrounds

Some students had a deeper understanding of their role in reconciliation than others. From the data collected, this was largely dependent on students' background experiences coming into the course and the amount of community interaction they had in the course that they individually sought out and engaged in. The background of the students varied. Some students were international students or newcomers to Canada, who were more connected to their own cultural roots than the western students in the course. Some students had learned about the

impacts of colonialism from Indigenous knowledge holders from previous experiences, whom they sought out based on their own curiosity and life circumstances. Interestingly, any previous formal mandatory education the students received around Indigenous cultures did not seem to positively impact their view of Indigenous peoples. For example, students referenced information they heard in the news or learned in high school history books, and a mandatory previous participation in a round dance, and how these were not actually reflective of the realities of the Indigenous-centered life they experience in the SL40 FN Design Build course. Some of the students were quite shy to engage with community members on their own, without guidance from the course instructors, tasks and community members. Other students were more outgoing, and initiated interactions with the community members on their own, which furthered their relationship-building skills and community understanding. The student participants in this research all seemed to like people and have the emotional capacity to work with people and a desire to develop these capacities but some felt like, they needed more support and guidance to develop relationships with community members.

Chapter 6: Conclusion

The Shoal Lake 40 First Nation (SL40 FN) Design Build transdisciplinary project-based course bridged engineering and architecture faculties with Indigenous peoples and their respective knowledges and realties. It took root from a partnership formed by an architecture professor and an SL40 FN community member and grew from their shared values of wanting to bring their people together, to learn from each other, and work with each other in respectful, harmonious, and reciprocal ways. The significance of the partnership was appreciated within the historical and cultural settings of the Winnipeg Aqueduct, and the understanding of how this civil development project has benefited the populations and economies of Winnipeg for over a hundred years at the cost of the populations and economies of SL40 FN. This context leads to the question of how diverse groups of people, historically and culturally at odds with each other, can overcome barriers of division and destruction to harmoniously co-create at their intersecting and polarized boundaries of existence in sustainable ways. Following this bigger philosophical question and guiding the focus of this research was the question: *how was students' learning impacted by participation in a transdisciplinary design-build course offered by the Faculties of Engineering and Architecture at the University of Manitoba in partnership with Shoal Lake 40 First Nation?* Central to this thesis research was transdisciplinarity, which aims to bring diverse peoples and their knowledges together to act on complex problems. A qualitative intrinsic case study drawing on the researcher's lived experiences and use of cultural-historical activity theory (CHAT) narrated the relational and rational thinking and practices of the student participants in the SL40 FN Design Build. Pre-existing engineering and architecture norms, rules and standards of social-technical divides, epistemological superiority, disconnection from people, place and self were disrupted along the journey of finding and building the connective and mutually

beneficial pathways supportive of a harmonious co-existence with the course's Indigenous partners.

This case study presents findings of students stepping beyond the boundaries of their disciplinary practices and background experiences and re-shaping their worldviews to be present in an ethical space (Ermine, 2007) with the Indigenous course partners. By entering and engaging in ethical space, the veil of previous understandings was identified and lifted to reveal a more authentic understating of the Elders' and SL40 FN community members' realities. Preconceived constructs of Indigenous culture and lived realities shifted as students participated in ceremonies, listened to community members' stories and the Elders' teachings, and engaged in the SL40 FN community and natural landscapes. Students negotiated their personal identities and positionalities, contemplating their upbringing, life experiences, and education, and how these shaped their views on Indigenous peoples and cultures in Canada.

The students were motivated to negotiate their identities and societal positionings, open to participate in new cultural activities, and willing to contribute to human-to-human relationships to learn from and appreciate the SL40 FN community's and Elders' knowledges and worldviews. This was not always a linear process with direct and clear connections to students' disciplinary design work, and therefore the process caused moments of uncertainties and doubts. However, there was space for the relationships to grow and develop, thus providing grounding in moments of uncertainty. Having the students work through the complete life cycle of a design and build while engaging in relationship building, enabled students to see a tangible final product that was co-created, which helped legitimize the transdisciplinary process. As Ermine (2007) states, it takes time for western peoples to explore these, new to them, fields of thoughts and realities embodied by Indigenous peoples and lands. Ermine (2007) also states that through this collective, sustained engagement, the "hidden values and intentions" that influence one's

behaviour and the cultural differences contributing to root issues will be revealed (p. 203). The findings from this case study revealed students identifying root issues of racism, and western norms about control and time as barriers to engaging in ethical space. Some students worked through fears of white privilege, learned that participating in the ceremony is the best way to learn about a culture, and questioned why institutional racism exists and what they can do to engage in reciprocity with Indigenous peoples.

Despite the students belonging to the groups of people benefiting from colonialism, at the cost of the SL40 FN's forced relocation, restriction to safe and reliable transportation in and out of their community, and access to clean drinking water, community members welcomed the students into their community and invited them to participate in their ceremonies and events. The students felt accepted for who they were and were motivated to respond to the negative legacies of colonialism and infrastructure development that favours one group of people over another, by learning how to be better people, have better relationships with Indigenous peoples, and provide better engineering and architecture services. Students formed an emotional connection with community members, and the relationships that blossomed provided students with deeper meaning and purpose for the project work. Both groups had a genuine interest to work with each other and learn from each other, and this ultimately fostered pathways for knowledge exchange and co-creation.

The project-based nature of the transdisciplinary course furthered students' development of their collaborative abilities to work with diverse stakeholders. These stakeholders included prefabrication and construction workers, professionals, and SL40 FN community members of . Out-of-the-classroom and off-campus activities, engagement in extra-disciplinary tasks, learning with the course instructors, and providing space to make mistakes were the tools that facilitated students' learning. Students were brought to the limits of their capabilities and knowledge and

had to trust in the expertise and guidance of the other stakeholders in translating their design ideas into a constructed reality. This fostered humility and awareness in the students; they realized that they did not know all the answers and learned with greater clarity how their work impacts the work of other professionals and people and how they are interconnected to their practices. Importantly, the student participants in this study were open to hearing the different perspectives shared in the course and had a willingness to change their perspectives and assumptions to work in harmony with the courses stakeholders.

For the students who learned more from the interactions with the Indigenous members of the course, their underlying focus was about understanding their own individual state of being, what makes them unique, what their strengths are, and what they contribute to and gain in knowledge exchange and relationship building with Indigenous peoples as it relates to their personal and career impact trajectories. For the students who learned from both the interactions of the Indigenous members and the technical nature of the project, their focus was on finding a balance between the states of doing and being in a diverse group. They provided insight on how even more balance between western and newly learned Indigenous perspectives and practices could be experienced for the next version of the course and wanted to understand how to collaborate more effectively with all stakeholders. For the students who learned more about design actualization and working across disciplines, their focus was on how to effectively integrate disciplinary practices to meet a client's needs. Overall, the students valued the teaching and learning environment of the design-build course in that it was empowering, exciting, affirming of their professional and personal goals, and a positive experience both in terms of learning outcomes and emotional satisfaction.

Limitations and Future Research

This research utilizes a western research approach to explore non-Indigenous students' learning experiences to gain insight into the educational impact of the novel transdisciplinary SL40 FN Design Build course. Since this course involves significant inclusion of Indigenous peoples and knowledges, a comprehensive understanding of SL40 FN Design Build course's impact, inside and outside of academia, cannot be fully understood without evaluating it from the SL40 FN community's and Indigenous-centered perspectives. In this study, I gathered feedback on the research findings from one SL40 FN community member and from the Elders on campus involved in the project. I also drew on the works of some Indigenous scholars, was mindful to not to perpetuate harmful colonialist mentalities, and I relied on my background experiences learning from Indigenous communities and non-western worldviews. However, the study would be enriched with the inclusion of the voices and perspectives of more SL40 FN community members who were involved in the SL40 FN Design Build. This research gains insight into the nature of the transdisciplinary SL40 FN Design Build course by assessing the impact on students' learning. Further insight into this particular type of teaching and learning environment can be explored by considering the impact the course had on the professors, the professionals outside of the university, and the community members who provided guidance in the course. Future work could also examine the role of masculine and feminine knowledge development in these types of courses and how to bring balance to the masculine and feminine dynamic.

I reflect on Simpson's (2016) perspective on strategies for change, which are to influence the system or create alternatives to the system, and her statement that "engagement with the system changes Indigenous peoples more than it changes the system" (p. 24). I recommend that future research and decisions made for courses similar to the SL40 FN Design Build course actively include Indigenous voices when considering if it is effective at what it aims to achieve.

This is essential given the founding principles of the course to house this mutual teaching and learning project within academic walls and systems as well as outside those walls. If Indigenous scholars were to look at this work, would they notice a paradigm shift in the students? Would they notice a positive impact in the SL40 FN community in ways that ultimately promote healing and the building of a reciprocal nation-to-nation relationship? If not, then what are engineering education and architecture education and their professions doing? How can we realign our efforts? For academia, and the faculties of engineering and architecture, to truly take responsibility our relations with Indigenous peoples, we must bring flexibility into the operational missions and resulting education structures to allow for intercultural learning. We must take risks, engage in uncertainty, bend the rules, and put in the efforts to truly find out what harmonious relationships and partnerships look like in the pursuit of knowledge exchange and expansion applied for the greater good of our collective communities. The SL40 FN Design Build course and this qualitative research is advancing this direction. To further support this type of transformative education, it is essential to support Indigenous resurgence and restitution of land.

Finally, I acknowledge that the English written word, prized in western research, is limited in exploring and communicating a more comprehensive understanding of the world and our role in it, as Indigenous languages could. Therefore, future work should make room for research methods to be conducted in, and publications written in Indigenous languages, which would expand the attempt to create pathways for understanding other ways of knowing. In the case of this research, I also could also have utilized modalities of photography and art to help describe and show the processes of navigating boundaries and the influences of the resulting paradigm shifts that students experienced in the course.

The SL40 FN Design Build course provided students with an experiential and relational opportunities to learn how the histories and current realities of the SL40 FN community members are connected to the design and build work of engineers and architects. Students gained clarity on how to learn from and work with Indigenous peoples in ways that do not perpetuate harm and destruction of the natural environment, and the interconnected social landscapes between western and Indigenous. The nation-to-nation relationships and project work in the SL40 FN Design Build course is a step in the direction of responding to the Truth and Reconciliation Commission of Canada's Calls to Action. In closing remarks, since the completion of Freedom Road in 2019, SL40 FN and their industry partners and funders have designed and constructed a water treatment plant and a new school and are in the process of constructing a powwow arbour.

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Appendices

Appendix A.1: Ethics Protocol Approval

University of Manitoba | Research Ethics and Compliance

Human Ethics - Fort Garry
208-194 Dafoe Road
Winnipeg, MB R3T 2N2
T: 204 474 8872
humanethics@umanitoba.ca

PROTOCOL APPROVAL

TO: **Jillian Seniuk Cicek**
Principal Investigator

FROM: **Zana Lutfiyya, Chair**
Education/Nursing Research Ethics Board (ENREB)

Re: **Protocol #E2019:054 (HS23022)**
Assessment of Cross-Faculty Design and Build Course

Effective: February 28, 2020 **Expiry:** February 28, 2021

Education/Nursing Research Ethics Board (ENREB) has reviewed and approved the above research. ENREB is constituted and operates in accordance with the current *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans.*

This approval is subject to the following conditions:

1. Approval is granted for the research and purposes described in the application only.
2. Any modification to the research or research materials must be submitted to ENREB for approval before implementation.
3. Any deviations to the research or adverse events must be submitted to ENREB as soon as possible.
4. This approval is valid for one year only and a Renewal Request must be submitted and approved by the above expiry date.
5. A Study Closure form must be submitted to ENREB when the research is complete or terminated.
6. The University of Manitoba may request to review research documentation from this project to demonstrate compliance with this approved protocol and the University of Manitoba *Ethics of Research Involving Humans.*

Funded Protocols: Please e-mail a copy of this Approval, identifying the related UM Project Number, to the Research Grants Officer at researchgrants@umanitoba.ca

Appendix A.2: Ethics Protocol Renewal

University of Manitoba | Research Ethics and Compliance

Human Ethics - Fort Garry
208-194 Dafoe Road
Winnipeg, MB R3T 2N2
T: 204 474 8872
humanethics@umanitoba.ca

RENEWAL APPROVAL

Effective: February 1, 2022 New Expiry: February 28, 2023

Principal Investigator:	Jillian Judith Seniuk Cicek
Protocol Number:	HS23022 (E2019:054)
Protocol Title:	*Assessment of Cross-Faculty Design and Build Course in Partnership with Shoal Lake 40 First Nation*

Andrea L Szwajcer, Chair, REB2

Research Ethics Board 2 has reviewed and renewed the above research. The Human Ethics Office is constituted and operates in accordance with the current *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans*- TCPS 2 (2018).

This approval is subject to the following conditions:

i. Any changes to this research must be approved by the Human Ethics Office before implementation.

ii. Any deviations to the research or adverse events must be reported to the HEO immediately through an REB Event.

iii. This renewal is valid for one year only. A Renewal Request must be submitted and approved prior to the above expiry date.

iv. A Protocol Closure must be submitted to the HEO when the research is complete or if the research is terminated.

Appendix B.1: TCPS2 Core Certificate

PANEL ON RESEARCH ETHICS
Navigating the ethics of human research

TCPS 2: CORE

Certificate of Completion

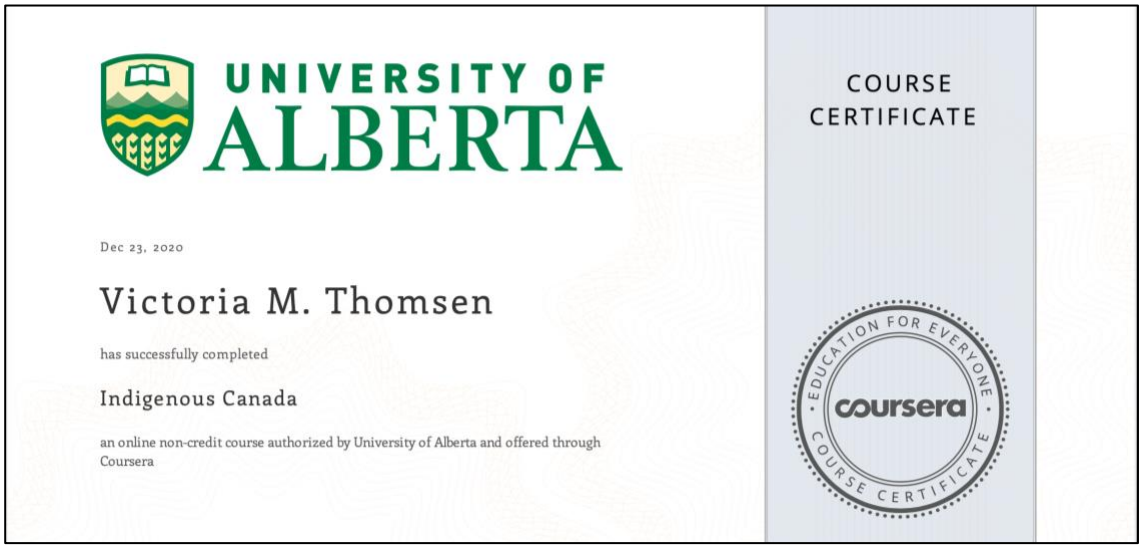
This document certifies that

Victoria Thomsen

has completed the Tri-Council Policy Statement:
Ethical Conduct for Research Involving Humans
Course on Research Ethics (TCPS 2: CORE)

Date of Issue: **17 November, 2020**

Appendix B.2: Indigenous Canada Certificate



UNIVERSITY OF ALBERTA

COURSE CERTIFICATE

Dec 23, 2020

Victoria M. Thomsen

has successfully completed

Indigenous Canada

an online non-credit course authorized by University of Alberta and offered through Coursera

EDUCATION FOR EVERYONE · coursera · COURSE CERTIFICATE

Appendix C.1: Email Recruitment for Potential Participants

Dear former ENG 4100/EVDS 3710 Student/TA/Instructor,

I'm contacting you to ask your willingness to participate in a small research study to help assess the delivery and learning outcomes of the course ENG 4100/EVDS 3710, offered Summer 2019/2021.

I am asking for students' permission to assess their coursework. Additionally, I'm seeking interview participants to discuss their experiences in the course.

The information from this study will be used to help us investigate Indigenous Initiatives in the Faculty of Engineering. Your participation is voluntary and will be held confidential.

A letter of Informed Consent further explaining the study and asking for your consent to participate, and an interview protocol are attached. Please email me your willingness to participate by signing the letter of Informed Consent and returning it to me at this email: **Contact information removed for privacy purposes** by **[date]**.

Thank you for considering being a participant.

Sincerely,
Jillian Seniuk Cicek

Appendix C.2: Email Reminder for Potential Participants

Dear former ENG 4100/EVDS 3710 Student/TA/Instructor,

I recently contacted you to ask your willingness to participate in a small research study to help assess the delivery and learning outcomes of the course ENG 4100/EVDS 3710, offered Summer 2019/2021.

I am asking for students' permission to assess their coursework. Additionally, I'm seeking interview participants to discuss their experiences in the course.

The information from this study will be used to help us investigate Indigenous Initiatives in the Faculty of Engineering. Your participation is voluntary and will be held confidential.

A letter of Informed Consent further explaining the study and asking for your consent to participate, and an interview protocol are attached. Please email me your willingness to participate by signing the letter of Informed Consent and returning it to me at this email: **Contact information removed for privacy purposes** by **[date]**.

Thank you for considering being a participant.

Sincerely,
Jillian Seniuk Cicek

Appendix D.1: Letter of Informed Consent to Participate in Research: 2019 ENG 4100/EVDS 3710 Students

[original on Institutional letterhead]

Research Project Title: "Assessment of Cross-Faculty Design and Build Course in Partnership with Shoal Lake 40 First Nation"

Principal Investigator and contact information:

** Contact information removed for privacy purposes**

[date]

Dear Former ENG 4100/EVDS 3710 Students/TAs:

I am carrying out a small research study with Master's graduate student, Victoria Thomsen, to help assess the delivery and learning outcomes of the course ENG 4100/EVDS 3710, offered in Summer 2019. You are receiving this letter because you were a former student/TA in this course and I hope you will consider being a participant in this study. The letter below tells you more about the study, in the formal language required by the University's Research Ethics Board, and asks for your informed consent to participate.

This consent form, a copy of which will be left with you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

The purpose of this research is to evaluate the delivery and learning outcomes of the course ENG 4100/EVDS 3710 by assessing students' learning outcomes and investigating stakeholders' retrospective perceptions of, and experiences in/with the course.

Should you agree to participate at this time, your participation will involve <u>all or a combination</u> of the following:

1. Granting permission for me to assess your course work, specifically the pre and post-course questionnaire and your portfolio, and use your course work as a source of data for this study. The course work will be used to assess the learning outcomes in ENG 4100/EVDS 3710.

2. Granting permission for me to use my observations/field notes of course learning activities as a source of data for this study.

3. One interview of approximately 60 minutes duration. The interview will be scheduled for Winter term 2021 online with Cisco Webex at a time convenient for you. The conversation during the interview will focus on your experiences in, and perceptions of, ENG 4100/EVDS 3710, now that the course is complete.

You may also consent to all, either #1 <u>and/or</u> #2 <u>and/or</u> #3, or none of the research activities.

Your participation in any or all of these activities is voluntary and will be held confidential.

The interview will be held at a time convenient for you, online using Cisco Webex and will be conducted by me and my graduate student research assistant. Field notes will be used to record any thoughts, feelings or impressions that I have in response to the discussion, as well as to record any non-verbal cues that pertain to the discussion. Only I will know who participates in the interview or not. The interview strategy will follow qualitative interviewing norms. As opposed to a structured question and answer session, the format will be conversational and relaxed. I will use a prepared interview guide with open-ended questions to guide the conversation (see attached), and will work to ensure the atmosphere is one in which you feel comfortable disclosing your feelings, perceptions, and opinions relative to your experiences in the ENG 4100/EVDS 3710 course. Participants will be given/read an Assurance of Confidentiality and asked to sign a Pledge of Confidentiality indicating that you will hold what is said by you or me during the interview in confidence, that you will not to discuss the interview outside of the session, and that any transcripts that have been sent to you for member checking are returned to me. The discussion during the interview will be recorded using a Sony audio recorder and/or the transcription software Dictate and will be recorded on Cisco Webex professional, after the session, the recording will be transcribed. The transcriber will sign a Pledge of Confidentiality indicating that s/he will not share identities or information from the interview participant. Your identity as an interview participant will be kept confidential, as well as any disclosures or data you provide. In the transcription and any written summary notes of the interview session, you will only be identified by a generic description with a letter or number, such as "Student 1." You will be invited to review the transcription, and then invited to review the interpretation of data and send any comments of clarification, correction, or additional thoughts and ideas to me. I will make any corrections/deletions/additions identified by you. All quotations, citations, or paraphrases of the data used for dissemination will be made generic with respect to unique personal features or identifiers, including but not limited to your gender, age, ethnicity, and speech habits. Direct quotes from the data used in publications will refer to the participant using only a general descriptor, such as "one student" or "Student 1."

My graduate student and I will keep all the consent forms and data from the interview, including the summary notes, the transcription and recording in a confidential and locked cabinet in our locked office or on my password protected computer in password-protected files. Once the recording has been transcribed, the recording will be permanently erased from the audio recorder, and securely erased from my computer files. All data and the consent forms from this study will be kept securely until the study and dissemination is complete. After that time, and not exceeding 5 years, all identifiable data from this study will be securely destroyed: electronic data will be destroyed securely; hard data will be destroyed by shredding the paper. The unidentifiable data will be kept until the data are no longer needed or until I retire.

Results from this study will be disseminated in the Faculty of Engineering at the University of Manitoba for the purposes of improvement of engineering education. Research findings from this study will also be presented at relevant conferences, and published in conference proceedings and/or in journals.

You will be mailed a $25 gift card to a store of your choice (i.e., Tim Hortons, Starbucks, the U of M Bookstore, Subway, etc.). Gift cards are for the interview as compensation for approximately 1 hour of your time.

Right to withdraw: Before providing written consent, you should be aware that you have the right to withdraw any of your comments and/or your data or withdraw completely from this study at any time, without prejudice, consequences, or penalty. You may express your desire to withdraw by contacting me via email, phone or mail using the contact information below. If you choose to withdraw from the study before the data are analyzed, your responses will be struck from all the data and your contact information destroyed. If you choose to withdraw from the study after the data are analyzed, the analyses will remain, as it will not be possible to separate your data from other data in the analyses, but your individual data

and contact information will be destroyed. In both cases, you will not be contacted in regards to the study again.

This project has been assessed as a minimal risk study. However, there may be the occasion when a participant may find the conversation emotional or upsetting. If this is the case, you can stop the interview at any time. You can also contact the University of Manitoba Student Counseling Centre by telephone at 204-474-8592.

Participants will benefit from this experience by having the opportunity to discuss their perceptions of, and experiences the ENG 4100/EVDS 3710 course.

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and /or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

My contact information is as follows:

** Contact information removed for privacy purposes**

The University of Manitoba may look at your research records to see that the research is being done in a safe and proper way.

This research has been approved by the Education and Nursing Research Board. If you have any concerns or complaints about this project you may contact any of the above-named persons or the Human Ethics Coordinator at 204-474-7122 or humanethics@umanitoba.ca. A copy of this consent form has been given to you to keep for your records and reference.

FIPPA Notification Statement:

Notice Regarding Collection, Use, and Disclosure of Personal Information by the University

Your personal information is being collected under the authority of *The University of Manitoba Act*. The information you provide will be used by the University for the purpose of evaluating the delivery and learning outcomes of the course ENG 4100/EVDS 3710 by assessing students' learning outcomes and investigating instructors/community stakeholders' retrospective perceptions of, and experiences in/with the course. Your personal information will not be used or disclosed for other purposes, unless permitted by *The Freedom of Information and Protection of Privacy Act* (FIPPA). If you have any questions about the collection of your personal information, contact the Access & Privacy Office (tel. 204-474-9462), 233 Elizabeth Dafoe Library, University of Manitoba, Winnipeg, MB, R3T 2N2.

Sincerely,

Jillian Seniuk Cicek

Please sign below to indicate your informed written consent to participate in this study.

I consent to participate in an interview for this research study, "Assessment of Cross-Faculty Design and Build Course in Partnership with Shoal Lake 40 First Nation."

Participant's signature	Date
Researcher's signature	Date

To receive a summary of the results of this study, please fill out this page and bring it to the interview, or return to:

** Contact information removed for privacy purposes**

Name: _____

I would like to receive a summary of the findings and/or any publications arising from study:

Yes _____ No _____ (please check one)

I prefer to receive the documents as an (check one)

☐ E-mail attachment to the following e-mail address:
_____

☐ Hard copy to the following mailing address:
_____

Participants can expect a summary of the findings by approximately Fall term 2021 or Winter 2022.

Appendix D.2: Letter of Informed Consent to Participate in Research: 2019 ENG 4100/EVDS 3710 Instructors

[original on Institutional letterhead]

Research Project Title: "Assessment of Cross-Faculty Design and Build Course in Partnership with Shoal Lake 40 First Nation"

[date]

Dear Summer 2019 ENG 4100/EVDS 3710 Instructors:

I am carrying out a small research study with Master's graduate student, Victoria Thomsen, to help assess the delivery and learning outcomes of the Shoal Lake 40 First Nation Design and Build course (ENG 4100/EVDS 3710), offered in Summer 2019. You are receiving this letter because you were an instructor in this course in Summer 2019 and I hope you will consider being a participant in this study. The letter below tells you more about the study, in the formal language required by the University's Research Ethics Board, and asks for your informed consent to participate.

This consent form, a copy of which will be left with you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

The purpose of this research is to evaluate the delivery and learning outcomes of the course ENG 4100/EVDS 3710 by assessing students' learning outcomes and investigating instructors' retrospective perceptions of, and experiences in/with the course.

Should you agree to participate at this time, your participation will involve the following:

1. A minimum of one interview of approximately 60 – 90 minutes duration. The interview will be scheduled for Winter term 2021 online with Cisco Webex at a time convenient for you. The conversation during the interview will focus on your experiences in ENG 4100/EVDS 3710, and your perceptions of students' learning in ENG 4100/EVDS 3710, now that the course is complete. (If you desire more than one interview, I would be happy to meet with you more than once.)

2. Granting permission for me to use my observations/field notes of course learning activities as a source of data for this study.

You may also consent to all, either #1 <u>and/or</u> #2, or none of the research activities.

Your participation is voluntary and will be held confidential.

The interview will be held at a time convenient for you, online using Cisco Webex and will be conducted by me and my graduate student research assistant at a time convenient for you. Field notes will be used to record any thoughts, feelings or impressions that I have in response to the discussion, as well as to record any non-verbal cues that pertain to the discussion. Only I will know who participates in the interview or not, unless you wish to disclose this information. The interview strategy will follow qualitative interviewing norms. As opposed to a structured question and answer session, the format will be conversational and relaxed. I will use a prepared interview guide with open-ended questions to guide the

conversation (see attached), and will work to ensure the atmosphere is one in which you feel comfortable disclosing your feelings, perceptions, and opinions relative to your experiences in/with the Shoal Lake 40 First Nation Design and Build /ENG 4100/EVDS 3710 course. Participants will be given/read an Assurance of Confidentiality and asked if they wish to sign a Pledge of Confidentiality indicating that you will hold what is said by you or me during the interview in confidence, that you will not to discuss the interview outside of the session, and that any transcripts that have been sent to you for member checking are returned to me. This is up to you to determine if you would like to follow this protocol. If you agree, the discussion during the interview will be recorded using a Sony audio recorder, the transcription software Dictate and will be recorded on Cisco Webex professional, after the session, the recording will be transcribed. The transcriber will sign a Pledge of Confidentiality indicating that s/he will not share identities or information from the interview participant. Your identity as an interview participant will be kept confidential, as well as any disclosures or data you provide. In the transcription and any written summary notes of the interview session, you will only be identified by a generic description with a letter or number, such as "one instructor" unless you wish to be known by your/another name/pseudonym. You will be invited to review the transcription, and then invited to review the interpretation of data and send any comments of clarification, correction, or additional thoughts and ideas to me. I will make any corrections/deletions/additions identified by you. All quotations, citations, or paraphrases of the data used for dissemination will be made generic with respect to unique personal features or identifiers, including but not limited to your gender, age, ethnicity, and speech habits. Direct quotes from the data used in publications will refer to the participant using only a general descriptor, such as "one instructor" or "one stakeholder" unless you direct me otherwise.

I will keep all the consent forms and data from the interview, including the summary notes, the transcription and recording in a confidential and locked cabinet in my locked office or on my password protected computer in password-protected files. Once the recording has been transcribed, the recording will be permanently erased from the audio recorder, and securely erased from my computer files. All data and the consent forms from this study will be kept securely until the study and dissemination is complete. After that time, and not exceeding 5 years, all identifiable data from this study will be securely destroyed: electronic data will be destroyed securely; hard data will be destroyed by shredding the paper. The unidentifiable data will be kept until the data are no longer needed or until I retire.

Results from this study will be disseminated in the Faculty of Engineering at the University of Manitoba for the purposes of improvement of engineering education. Research findings from this study will also be presented at relevant conferences, and published in conference proceedings and/or in journals. You will be provided with copies of all disseminations of the study.

Right to withdraw: Before providing written consent, you should be aware that you have the right to withdraw any of your comments and/or your data or withdraw completely from this study at any time, without prejudice, consequences, or penalty. You may express your desire to withdraw by contacting me via email, phone or mail using the contact information below. If you choose to withdraw from the study before the data are analyzed, your responses will be struck from all the data and your contact information destroyed. If you choose to withdraw from the study after the data are analyzed, the analyses will remain, as it will not be possible to separate your data from other data in the analyses, but your individual data and contact information will be destroyed. In both cases, you will not be contacted in regards to the study again.

This project has been assessed as a minimal risk study. However, there may be the occasion when a participant may find the conversation emotional or upsetting. If this is the case, you can stop the interview at any time. (For instructors only: You can also contact the Employee & Family Assistance Program at 1-800-387-4765.)

Participants will benefit from this experience by having the opportunity to discuss their perceptions of, and experiences the Shoal Lake 40 First Nation Design and Build/ENG 4100/EVDS 3710 course.

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and /or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

My contact information is as follows:

** Contact information removed for privacy purposes**

The University of Manitoba may look at your research records to see that the research is being done in a safe and proper way.

This research has been approved by the Education and Nursing Research Board. If you have any concerns or complaints about this project you may contact any of the above-named persons or the Human Ethics Coordinator at 204-474-7122 or humanethics@umanitoba.ca. A copy of this consent form has been given to you to keep for your records and reference.

FIPPA Notification Statement:

Notice Regarding Collection, Use, and Disclosure of Personal Information by the University

Your personal information is being collected under the authority of *The University of Manitoba Act*. The information you provide will be used by the University for the purpose of evaluating the delivery and learning outcomes of the course ENG 4100/EVDS 3710 by assessing students' learning outcomes and investigating instructors' retrospective perceptions of, and experiences in/with the course. Your personal information will not be used or disclosed for other purposes, unless permitted by *The Freedom of Information and Protection of Privacy Act* (FIPPA). If you have any questions about the collection of your personal information, contact the Access & Privacy Office (tel. 204-474-9462), 233 Elizabeth Dafoe Library, University of Manitoba, Winnipeg, MB, R3T 2N2.

Sincerely,

Jillian Seniuk Cicek

Please sign below to indicate your informed written consent to participate in this study.

I consent to participate in an interview for this research study, "Assessment of Cross-Faculty Design and Build Course in Partnership with Shoal Lake 40 First Nation."

_____

Participant's signature Date

Researcher's signature Date

To receive a summary of the results of this study, please fill out this page and bring it to the interview, or return to:

** Contact information removed for privacy purposes**

Name: _____

I would like to receive a summary of the findings and/or any publications arising from study:

Yes _____ No _____ (please check one)

I prefer to receive the documents as an (check one)

□ E-mail attachment to the following e-mail address:
_____

□ Hard copy to the following mailing address:
_____

Participants can expect a summary of the findings by approximately Fall term 2021 or Winter 2022.

Appendix D.3: Pledge of Confidentiality for Interview Participants

I agree to hold what is said during this interview by the researcher and me in confidence, and will not discuss this interview outside of this session. I agree to return or destroy any transcripts that have been sent to me for member checking.

Date: _____

Name of Participant (Print): _____

Signature of Participant: _____

Appendix D.4: Pledge of Confidentiality for Research Assistants

Faculty of Engineering
Centre for Engineering Professional
Practice and Engineering Education

Centre for Engineering Professional
Practice and Engineering Education
335 Stanley Pauley Engineering
Building (SPEB), 97 Dafoe Rd
Winnipeg, MB R3T 5V6
Telephone: 204-474-9722
Facsimile: 204-474-7676
Email: ce2p2e@umanitoba.ca

Research Project Title: "Assessment of Cross-Faculty Design and Build Course in Partnership with Shoal Lake 40 First Nation"

Principal Investigator and contact information: Jillian Seniuk Cicek
Centre for the Engineering Professional Practice and Engineering Education
SP-333 Stanley Pauley Engineering Building
97 Dafoe Road
University of Manitoba
Office: 204-474-9698
Jillian.SeniukCicek@umanitoba.ca

October 4, 2020

Oath of Confidentiality for Research Assistants

I agree to hold the privacy and identity of all participants in this study, **"Assessment of Cross-Faculty Design and Build Course in Partnership with Shoal Lake 40 First Nation"** in confidence, and will not discuss these details with anyone but the Principal Investigator and research team. I agree to return or destroy any identifiable data that have been sent to me for checking or analyses.

Date: October 5, 2020

Name of Researcher (Print): Victoria Thomsen

Signature of Researcher: _____

The University of Manitoba is located in Treaty 1 traditional territory of Anishinaabeg, Cree, Oji-Cree, Dakota, and Dene Peoples, and the homeland of the Métis Nation.

Appendix D.5: Assurance of Confidentiality to Interview Participants

This standard text will be used for all interviews. The moderator will read or paraphrase the following:

Thank you for agreeing to participate in this study. Everything you say will be held in confidence. The purpose of this interview is to evaluate the delivery and learning outcomes of the course ENG 4100/EVDS 3710 by assessing students' learning outcomes and investigating stakeholders' retrospective perceptions of, and experiences in/with the course. The questions have been designed to explore these areas. The goal is to see our time together as a relaxed conversation and not a structured question-and-answer period. You are free to withdraw any of your comments or withdraw completely from this study at any time, and you are under no obligation to answer any of the questions. The interview will be recorded using a Sony audio recorder, the transcription softwear Dictate and will be recorded using Cisco Webex professional. The recording will be transcribed and the transcriber will sign a Pledge of Confidentiality. When I summarize the recording and report the results of the study, I will use a pseudonym to identify you, and will not use any quotations that would identify you specifically. After I have summarized the recording, the summary will be returned to you for your review, and the recording will be securely destroyed. As mentioned earlier, all comments you provide will be held in confidence. As well, we ask that you agree to also hold what is said during this interview by you in confidence, and that you do not discuss this interview outside of this session, and that any transcripts that have been sent to you for member checking are returned to me. Do you have any questions about these procedures?

Appendix E.1: Interview Questions for Instructors

1. When you were designing the design build course what learning objectives, for students, did you focus on and why? What did you want the students to learn?
2. From your perspective, what did students learn from the design and build course? How did it relate to your learning objectives?
3. What were some of the key factors that contributed to the students learning?
4. From your perspective, what were the peaks and troughs/ups and downs that students experienced during this design and build course?
5. From your perspective, how did these 'peaks and troughs' affect students' learning?
6. What else did you observe about students' learning?
7. How did you observe students' learning?
8. What did students' learning look like?
9. We're there different stages of students' learning?
10. Did all students' learn in the same way?
11. Was learning different in the classroom, in the engineering village, and in the Shoal Lake 40 First Nation community?
12. In coming to the Shoal Lake 40 First Nation (for the first time)/in having UM students and instructors from the design & build come to Shoal Lake 40 First Nation:

- We're you prepared?
- What were your expectations?
- Were your expectations met? Exceeded?
- What could you do better the next time you visit our community? A First Nation?
- What could we do better the next time?
- What did you learn from the community?
- What did we learn from each other?
- What were the 3 best things that came out of this project for you?

13. When was the deepest learning for students, in your opinion?
14. How was student learning similar or different to other courses you have taught that included Indigenous knowledges and or perspectives?
15. How would you approach a new, similar design build project in the future?
16. What did you learn?

17. Is there anything else you'd like to tell us about this experience?
18. Dr. Seniuk Cicek/Victoria, do you have any questions you would like to ask?
19. What pronouns do you prefer to go by?

Prompts:

Is there anything more that you can remember about...?

Can you tell me more about...?

Can you explain/expand upon…?

Can you please repeat…?

What do you mean by…?

Appendix E.2: Interview Questions for Students

Questions about your experience participating in the Design Build Course

1. What was your experience like as a student in the course? Tell me about it…
2. Tell me about your time in the Design studio. What was the most memorable about this experience? What was difficult? What was enjoyable? Is there anything else you'd like to tell me about this time?
3. Tell me about your time in the Sustainability-in-Action Facility. What was the most memorable about this experience? What was difficult? What was enjoyable? Is there anything else you'd like to tell me about this time?
4. Tell me about your trips to Shoal Lake 40 First Nation during this time (there were 2 trips: one to meet community and choose a place to build; one to attend the powwow). What was the most memorable about this experience? What was difficult? What was enjoyable? Is there anything else you'd like to tell me about this time?
5. Tell me about your time in Shoal Lake 40 First Nation, during the build week. What was the most memorable about this experience? What was difficult? What was enjoyable? Is there anything else you'd like to tell me about this time?
6. In coming to the Shoal Lake 40 First Nation (for the first time)/in having UM students and instructors from the Design & Build come to Shoal Lake 40 First Nation:

- We're you prepared?
- What were your expectations?
- Were your expectations met? Exceeded?
- What could you do better the next time you visit our community? A First Nation?

- What could we do better the next time?
- What did you learn from the community?
- What did we learn from each other?
- What were the 3 best things that came out of this project for you?

7. What was the teaching environment like for you? Was it similar to other courses you took? Tell me about this.
    a. How do you think the teaching environment influenced your learning?
8. How did the course make you think about your career and role as an engineer/architect?
9. How have you used any of your learnings from the course in your further studies or work?
10. How would you approach a new, similar project in the future?
    a. Is there anything you would do differently? Or wish that was different?
11. Have you engaged in further cultural awareness courses or events? Tell me about this.
12. Do you think learning from Indigenous knowledge holders is valuable to have in the engineering curriculum? Why or why not?
13. Where do you think the greatest links between engineering/architecture work and Indigenous ways of knowing are?
14. Are there other learning opportunities you have had in engineering related to Indigenous peoples and their worldview?
15. How did you feel about your experience in the course overall?
16. What were some of your learnings?
17. Do you remember experiencing any strong emotions?
    a. What were they like? What do you think caused them, did you learn anything from them?
18. What were the ups and downs you experienced during the course?
    a. How did they impact your learning?
19. Did you experience anything surprising during the course?
20. Why did you want to do this interview?
21. Dr. Seniuk Cicek/Victoria, do you have any questions you would like to ask?
22. Is there anything else you'd like to tell us about this experience?
23. What pronouns do you prefer to go by?

Prompts:

Is there anything more that you can remember about...?

Can you tell me more about...?

Can you explain/expand upon…?

Can you please repeat…?

What do you mean by…?

Appendix F.1: Example of Coding

Elders' Teachings On Campus
Part One: Providing a cultural context for the project

"[1TLE]Elder Meade provided initial [1TFL]context into the project. He opened discussions regarding the cultural elements and traditions of Indigenous people." (p. 5 Rebecca portfolio)	[1TLE]ELDER MEADE [1TFL]INDIGENOUS CONTEXT
"The [2TFL]medicine wheel, [3TFL]seven sacred teachings, [4TFL]water sacredness, and relevance of water to the project were the core teachings that were present throughout the project." (p. 5 Rebecca portfolio)	[2TFL] "MEDICINE WHEEL" [3TFL] "7 SACRED TEACHINGS" [4TFL]"WATER"
"we had the opportunity to utilize [5TFL]resources and services on campus to assist our understanding of [6TFL]traditional knowledge and [7TFL]values. We partook in [8PDR]consultations with a local Elder on campus, [9TLE]Elder CS, who works in residence at [10R]Migizii Agamik, "Bald Eagle Lodge". The importance of the [11TFL]seven sacred teachings, [12TFL]directional association, [13TFL]connection to the environment, importance of life and [14TFL]gender roles, and the use of [15TFL]traditional knowledge in contemporary design were shared with us." (p. 4 Liam interview)	[5TFL] "CAMPUS RESOURCES" [6TFL]TK [7TFL]"VALUES" [8PDR] CONSULT [9TLE] ELDER CARLO STONE [10R] "MIGIZII AGAMIK" [11TFL] "7 SACRED TEACHINGS" [12TFL]MEANING OF DIRECTIONS [13TFL]"CONNECTION TO ENVIRONMENT" [14TFL]"GENDER ROLES" [15TFL]"TK IN CONTEMP DESIGN"
"[16TFL]LOVE - RESPECT - COURAGE - HONESTY – HUMILITY - WISDOM – TRUTH" (p. 1 Liam portfolio)	[16TFL] 7 SACRED TEACHINGS (listed)
"the [17O]information they [Elder M & CS] provided on utilizing traditional knowledge was [18O]key to delivering a project design that was respected by the community." (p. 4 Liam portfolio)	[17O] DESIGN RESPECTED BY SL40FN [18FE]ELDER INFO "KEY"
"The [19FE]teachings provided by the Elders outside of Shoal Lake were crucial, one key message that did come across was that [20TFL]traditions do vary from tribe to tribe, family to family. Indigenous culture is rich and diverse within Manitoba. Thus, the [20SEP]teachings provided outside of Shoal Lake may not entirely represent the traditional practices by the people of Shoal Lake No. 40." (p. 5 Rebecca portfolio)	[19FE] ELDER TEACHING "CRUCIAL" [20TFL] "TRADITIONS VARY" [20SEP] TRADITIONS VARY SO NEGOTIATE EXPECTATIONS

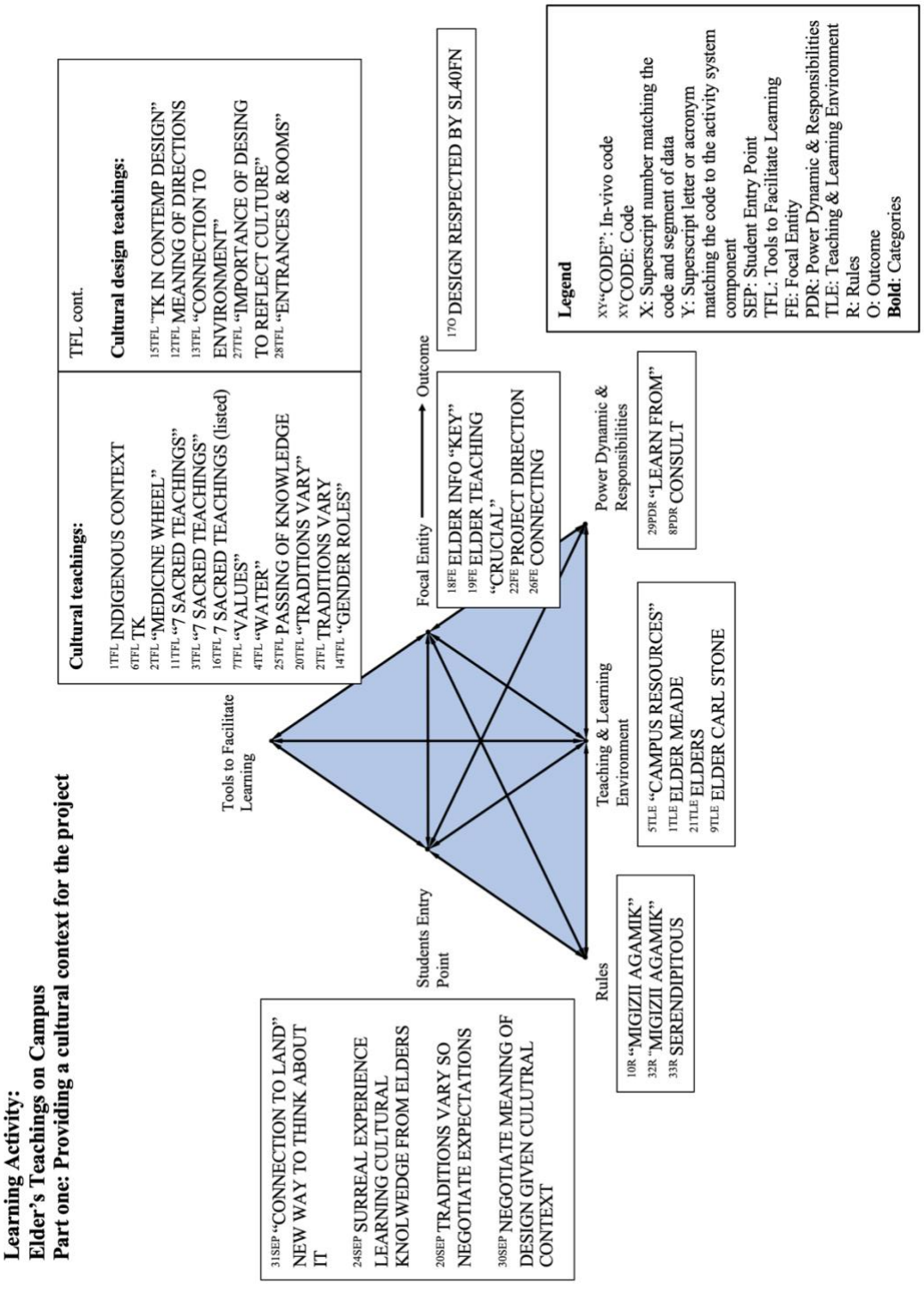
F

Alphabetized list of codes:

“CAMPUS RESOURCES”
“CONNECTION TO ENVIRONMENT”
CONNECTING
“CONNECTION TO LAND”
CONSULT
DESIGN RESPECTED BY SL40FN
ELDER INFO “KEY”
ELDER TEACHING “CRUCIAL”
ELDER MEADE
ELDERS
ELDER CARL STONE
“ENTRANCES & ROOMS”
“GENDER ROLES”
“IMPORTANCE OF DESIGN TO REFLECT CULTURE”
INDIGENOUS CONTEXT
“LEARN FROM”
“MEDICINE WHEEL”
MEANING OF DIRECTIONS
“MIGIZII AGAMIK”
“MIGIZII AGAMIK”
PROJECT DIRECTION
PASSING OF KNOWLEDGE
SURREAL EXPERIENCE LEARNING CULTURAL KNOWLEDGE FROM ELDERS
SERENDIPITOUS
“TRADITIONS VARY”
TRADITIONS VARY
TK
“TK IN CONTEMP DESIGN”
“VALUES”
“WATER”
“7 SACRED TEACHINGS”
“7 SACRED TEACHINGS”
7 SACRED TEACHINGS (listed)

F

Appendix F.2: Example of CHAT Learning Activity System



Summary of Learning Activity System:

On campus resources were utilized to provide students with culturally relevant teachings from Elder Meade and Elder Carl Stone. The Elders played the role of wise counsel, which the students respected. The teaching from Elder Carl Stone was not planned and developed spontaneously. An important teaching, discussed in the next section, came from that spontaneous interaction. The students learned about the Indigenous culture and traditions, how they interact with the world around them and make sense of it, especially when building infrastructure for their community. The students realized that the information they received from the Elders would help them interact with the SL40 FN community, meet them where they are, and discuss design considerations. As a result, students began negotiating what they had previously learned about design in their program and what the Elders were sharing with them. This created a shift in some of the student's perspectives that there will be culturally significant things to consider when designing with Indigenous people. These things were briefly identified, but the understanding of them and the meaning behind them was still being processed by the students who had yet to interact with the community of SL40 FN.

Appendix F.3: Example of Narrative Formation

Formation of the narrative from codes, activity system, and participant quotes

Elders' teachings on campus

Part one: Providing a cultural context for the project

On campus Elders', Elder Meade and Elder Carl Stone provided prominent cultural teachings on the [2TFL]"MEDICINE WHEEL", and the [11TFL]"7 SACRED TEACHINGS" of [16TFL]"LOVE - RESPECT - COURAGE - HONESTY – HUMILITY - WISDOM – TRUTH" (p. 1 Liam). Furthermore, they shared their perspectives on Indigenous [7TFL]"VALUES", significance of [4TFL]"WATER", [25TFL]PASSING OF KNOWLEDGE and [14TFL]"GENDER ROLES". At

[10R]"MIGIZII AGAMIK", the Indigenous Student Centre, Elder Carl Stone taught about the buildings' culturally significant architecture and how [15TFL]"TRADITIONAL KNOWLEDGE IS USED IN CONTEMPORY DESIGN". He discussed how the orientation of [28TFL] "ENTRANCES & ROOMS were selected and based from cultural teachings of [12TFL]THE FOUR DIRECTIONS and [13TFL]"CONNECTIONS TO THE ENVIRONMENT". The Elders were viewed as wise knowledge holders in which students "partook in [8PDR]consultations with" (p. 4 Liam interview) and [31PDR]"LEARNED FROM".

The Elders' teachings mediated the non-Indigenous students' understanding of Indigenous peoples and perspectives. Some students began negotiating their western engineering and architecture understanding of design.

> *Talking with the Elders' and getting to know their perspectives and even when we were getting a tour of Migizii Agamik it was a way that we were able to [29PDR]learn from them and how they talked about things, how they talked about [30SEP]the different meanings of things and the importance of a house or things designed to reflect on the culture, specifically when we were looking through the building and talking about the different entrances and how you enter the building and certain rooms. Also [31SEP]this kind of connection to the land which was really brought through the whole course [started with Elder Meade and Elder Carl Stone]. I think in general before taking the design build course there isn't really any courses that are mandatory that kind of touch on any of these kind of ideas which I thought was really interesting. So the Elders' taught us to think about things a little differently than how we would usually do and that made me give things a little bit more thought. (p. 5 Kai interview)*

Another student, who valued learning from these teachings, also learned that "[20SEP]teachings provided outside of SL40 FN may not entirely represent the traditional practices by the people of

SL40" (p. 5 Rebecca portfolio). Therefore, learning from the people of SL40 FN directly is essential. To rely explicitly on knowledge out-of-the-community echoes another students' insight on letting prior online research completely dictate one's expectations of the community.

> *I think it's really important that if a student's coming to visit any community whether it's Indigenous or not that they go with an open mind and really try to learn from the members of the community because it's so easy to go in and be like, I did my research. (p. 11 Dana interview)*

Some students were motivated to listen to these new teachings of Indigenous culture and design when it was connected to the unique people the design process was serving.

> *It was a [24SEP]surreal experience, being able to listen and appreciate the cultural values and teachings that are so important. Gaining a better sense of the [25TFL]way stories, lessons, values and so on are passed on to others, and our group. It was a reminder to all of us that [26FE]this was for real people. (p. 6 Owen portfolio)*