HUMANITARIAN ENGINEERING IN THE ENGINEERING CURRICULUM

by

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A thesis submitted to the
Department of Civil Engineering
in conformity with the requirements for
the degree of Doctor of Philosophy

Queen’s University
Kingston, Ontario, Canada
August 2008

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Abstract

There are many opportunities to use engineering skills to improve the conditions for marginalized communities, but our current engineering education praxis does not instruct on how engineering can be a force for human development. In a time of great inequality and exploitation, the desire to work with the impoverished is prevalent, and it has been proposed to adjust the engineering curriculum to include a larger focus on human needs. This proposed curriculum philosophy is called humanitarian engineering.

Professional engineers have played an important role in the modern history of power, wealth, economic development, war, and industrialization; they have also contributed to infrastructure, sanitation, and energy sources necessary to meet human need. Engineers are currently at an important point in time when they must look back on their history in order to be more clear about how to move forward. The changing role of the engineer in history puts into context the call for a more balanced, community-centred engineering curriculum.

Qualitative, phenomenographic research was conducted in order to understand the need, opportunity, benefits, and limitations of a proposed humanitarian engineering curriculum. The potential role of the engineer in marginalized communities and details regarding what a humanitarian engineering program could look like were also investigated. Thirty-two semi-structured research interviews were conducted in Canada and Ghana in order to collect a pool of understanding before a phenomenographic analysis resulted in
five distinct outcome spaces.

The data suggests that an effective curriculum design will include teaching technical skills in conjunction with instructing about issues of social justice, social location, cultural awareness, root causes of marginalization, a broader understanding of technology, and unlearning many elements about the role of the engineer and the dominant economic/political ideology. Cross-cultural engineering development placements are a valuable pedagogical experience but risk benefiting the student disproportionately more than the receiving community. Local development placements offer different rewards and liabilities.

To conclude, a major adjustment in engineering curriculum to address human development is appropriate and this new curriculum should include both local and international placements. However, the great force of altruism must be directed towards creating meaningful and lasting change.
Acknowledgments

This dissertation represents much more than an academic exercise — it has been an incredible personal journey. The past four years have given me the opportunity to immerse myself into a variety of research fields, but it has also taught me much about who I am and how I would like to live my life. This journey has been shaped by many people and I can hardly bear to think of where this work might have gone, if anywhere at all, without the generous contributions and encouragement from a large number of people. This work is truly shaped by the labour of many others.

I have been very fortunate to work with Kevin Hall, who I believe introduced the term Humanitarian Engineering to Queen’s University, and who gave me an opportunity to research something that I really wanted to research. I cannot imagine where else I, or anyone else, could have possibly had this opportunity. From the very beginning, Kevin encouraged me to seek out what I really wanted to do and insisted that the practicalities would take care of themselves. His creative ways to fund my endeavours and his constant stretching of boundaries helped this to occur.

Jon Pharoah was my supervisor when I began my PhD and although we had to break academic ties, my friendship with him continues to mean a lot to me. I am very pleased that our friendship was strong enough to stand during the difficult time that a change in project and supervision can be. As a young professor building up his research lab, Jon let our personal relationship take priority over academic achievement, and our relationship
has been a blessing as a result. The past five years of running and conversing about energy, technology, society, politics, and religion have been a tremendous pleasure.

Many other professors at Queen’s University have contributed to my work. Caroline Baillie has taught me much about engineering education, social justice, and research methodologies. I do not want to think about what my thesis would look like without my collaborations and conversations with her. Gary vanLoon has been a wonderful support over the past four years as well. Not only was teaching with him an absolute pleasure, but his advice and wisdom has made him one of my most influential mentors. I have imposed myself on many other professors at this university who have kindly given me their time and ideas: Richard Day, Luke Bisby, Darko Matovic, Tim Bryant, Urs Wyss, Kunal Karan, Tom Harris, Rosemary King, Sheryl Bond, Marcus Taylor, Mark Hostetler, Bruce Berman, David McDonald, Malcolm Peat, Kristan Aronson, and Christian Leuprecht. Each of these faculty members, in their own way opened my eyes to new ways of thinking about my dissertation.

Without fellow graduate students, the academic process would have been quite dull. Conversations, both academic and personal with Imran Ali and Jamie Miller helped me learn how to articulate my understanding of technology and development. My friendships with these and other grad students, I’m sure, will form my lasting memory of graduate school: Erin, Whitney, Lesley, Sam, Abbas, Chris, Geof, Andy, Jana, Sean, Tom, Bryce, Mark, Alex, Dan, Brian and Frank. In addition, the participants in the Humanitarian Engineering Discussion Group and the Technology Action Group have played a vital component of my academic and personal life over the past four years.

Several contacts that I made in Ghana hugely influenced this work and I still often find myself reflecting on their wisdom. Mma. Esi Awuah, Benson Ngugi, and George Obeng each greatly influenced my thinking and touched my heart with their ideas. Being a stranger in a foreign land, I was thankful for the many Ghanaian folks who helped make that important stage of my dissertation go relatively smoothly by opening their homes,
providing rides, giving directions, sharing meals, and teaching me about their country.

Spiritual mentors have played a critical part of this journey as well. It was, in fact, during a weekend visiting Oka Abbey, a Trappist Cistercian monastery, and speaking with Brother Benedict Vanier, that encouraged me to undertake this current project. The Geneva Ministry, under the excellent leadership of both Phil Apol and Steve Kooy, has been an important place of grounding over the past eight years, especially in times of anguish and frustration. I am particularly thankful for my friendships with Phil and Steve, Jason Pridmore, Jon Sears, and Randy Elzinga. Todd Stelmach has been a great inspiration in understanding and living the message of the social gospel. The folks at Martha’s Table give me the change in pace I often need.

I have been passing my writings on to several people since very early on in my project. I find making clearly written arguments to be very challenging and I am very thankful for the proof-reading and editing done by Jeannie, Anne, Chris, John, Nate, Ivan, Dan, and many others. Chris Smart requires a special acknowledgement as he has been encouraging me with suggestions and thorough critiques since the very beginning of my project. This thesis would be much worse without these people.

My mother, father, sisters and their families, in-laws, and much of my large extended family have all had an important role in this endeavour as well. Kind words, timely phone calls, or a simple joke have all helped me regain perspective when I’ve started taking life too seriously. And finally, I have left the most important person to last. My wife Heather has been beside me since the very beginning and throughout the past 4 years of great growth and change. The growth and change has often been scary, but it seems easier to handle with her love. I am looking forward to not being a student with her.

I would like to sincerely thank all of the many people mentioned above because of their role in this document. Thank you.
Dedicated to Heather, who has allowed her journey to be my journey, and my journey to be her journey. May we go together into the blurry unknown with both fear and comfort.
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Chapter 1

Introduction

I see the engineering profession as having a fundamental ethical responsibility to assist in local, national, regional and global moves towards a more socially and ecologically sustainable society. – Stephen Johnson

Let me challenge all of you to help mobilize global science and technology to tackle the interlocking crises of hunger, disease, environmental degradation and conflict that are holding back the developing world. – Kofi Annan, addressing the engineering profession

Technology is an attitude of mind, not an assemblage of artefacts. – Chinua Achebe

In 1878, Andrew White, the first president of Cornell University, predicted that with university graduates pouring into national and local governments and media positions, corruption would come to an end and pure ideals would prosper until one day they governed the entire world [1]. In the 1860s, the electric telegraph was predicted to bring peace, concord, and unity to the world, making ‘muskets into candlesticks’ [2]. The same things were said in the 1920s about the radio [2] and in the 1990s about the cell phone [3].
Backed by this optimism, engineering education has always been seen as a very noble
endeavour, but we have not realized the utopian dreams predicted by both higher educa-
tion and technological advancements. Consider the story of the North Kivu Province of
the Democratic Republic of Congo (DRC).

The North Kivu Province is known for its beautiful forests, mountains, and wildlife,
such as the endangered eastern lowland gorilla. It is also known for its rich deposits of
minerals, including columbo-tantalite, or coltan. Unfortunately, it is also known for the
increasing number of internally displaced people, displaced because of a fierce war be-
tween the government army, rebels, renegade troops, and child soldiers. There are ethnic
tensions at the heart of this war, but economic interests which led to illegal mining and
trading in rebel-held territories, have fuelled the war since 1998 — the deadliest war since
WWII [4]. Those closely connected to this war agree that it is now an economic war and
not an ethnic war [4].

Tantalum, a white powder and the heat-resistant derivative of coltan, is necessary for
most high-tech electronics, including cell phones, DVD players, laptop computers, and
even some toasters. No modern gadget could survive without coltan, of which 80% of the
world’s deposits are in the Congo [5]. Many foreign mining companies, including up to
12 Canadian mining companies operate in the North Kivu Province and are experiencing
significant financial success [6], while many children in the region must worry about food
security and have very little opportunity outside of being a soldier or a miner. Coltan
mining has driven many Congolese farmers off of their fertile land and helped fund this
bloody civil war. Journalist George Monbiot says that “the misfortune of the Congolese is
that they possess tremendous natural wealth” [7].

University engineering graduates are involved in all stages of the development of the
cell phone, including the often exploitative way in which its raw materials are extracted.
While there are many engineering graduates who use their skills to improve the human
situation, higher education and technological advancements have not brought the anticipated outcome. This must cause us to challenge both the process and motivation behind engineering education.

1.1 Science, technology, and poverty

Science is the process of investigating natural phenomena in order to produce knowledge about the world. Technology is literally translated from the Greek (tekno + logia) to mean the theory behind the systematic treatment of an art, craft, or technique. Using these definitions, it is easy to argue that both science and technology have existed in every society throughout human history. Human living requires a certain amount of rational, empirical knowledge of the physical, chemical, biological, and social world. Not only does a deeper understanding of the surroundings create a greater sense of awe, but this understanding is often useful for survival or maturation. Application of knowledge in increasingly sophisticated ways has resulted in technical innovations such as the plough, the steam engine and the Internet, all of which have played a role in the evolution and development of societies. Today, both science and technology have come to be cultural icons of prestige, power, progress, and wealth. In order to take advantage of this speculation, policy makers in most countries in the world rank science and technology education at or near the top of their priorities for economic development and progress.

Technology has created and will continue to create many benefits, but these benefits have not been distributed equitably. While the current global economic system has created great riches through technology, it has also resulted in more impoverished people in the world today than ever before [8]. In fact, it has been seen and often discussed (see [9], for example) that the rising levels of affluence for some and the growing poverty for others are not only connected to the demographic expansion, but are also the consequence of technological development itself; many technologies benefit the wealthy at the expense of the
poor. Laptop computers and cell phones, for example, are advantages for those who can afford them but at the same time, the raw materials from which they were manufactured may have been obtained in an exploitative way, as in the DRC. Even when technology is obtained or developed from more ethical or legitimate sources, the rapid increase in economic growth is leading to the growth of a ‘technological divide.’ In the process, the poor, those with disabilities, and the elderly become increasingly marginalized [10].

Poverty is a physical phenomenon, but also a political one. C.T. Kurien defines poverty as the “socio-economic phenomenon whereby the resources available to a society are used to satisfy the wants of the few while the many do not have even their basic needs met” [11]. This definition suggests that poverty is essentially a social issue and only secondarily a material or physical one. The increasing levels of poverty are evident in the United Nations’ 2007/2008 Human Development Report, which states that over 80% of the world’s population lives in countries where income differentials are widening [8]. While it is obvious that the world’s wealth cannot be spread perfectly evenly, there is a need to reverse the trend and shrink the gap between the rich and the poor.1

Ironically, technology is also often discussed as a key to poverty reduction, humanitarian relief work, and human development [13]. Yet, most humanitarian, human development and aid workers have minimal technical training. There are many reasons to train engineers to think about using their skills for meeting human need, although this is not officially done at most universities. In fact, when addressing the problems of the poor and marginalized, one does not typically think of engineers or engineering; engineering is often thought to exist for the needs of industry or academia. But the input of engineers is required. Economist Jeffery Sachs says that we need to “draw the world’s leading scientists and engineers into the challenges of the poorest of the world” [14].

1While there is a minority of people who oppose this statement, it is an important normative basis for this thesis. While moral and ethical arguments are often cited as reasons for reducing the disparities, concerns such as global security, market access, social harmony, political stability, and environmental protection are more convincing in the current market hegemony. See [12] for an interesting discussion connecting poverty and wealth.
The predominant model of engineering education does not sufficiently equip students to work for social justice\(^2\) and against social exclusion and marginalization. Engineering students are often unclear about their role in larger social issues [16]. Graduating engineering students typically rate their awareness of ethical, political, or social issues as quite low.\(^3\) Worse, according to a recent National Academy of Engineering survey, engineers are given very little credit for improving the general quality of life, saving lives, protecting the environment, or caring about their community [17]. At the same time, engineering schools are suffering from declining enrollment and a declining applicant pool [18], and many of those who are trained as engineers are deciding to work in alternate fields.

A new engineering education model should be considered. Engineering educator Ursula Franklin, in her 1989 Massey Lectures, said that it is important to connect knowledge to a social agenda [19]. A university, she says, must provide a bridge for interaction with the larger community [10]. The needs of the larger community can only be addressed through engineering education that teaches a broader perspective of technology. Franklin says that technology is best defined as practice, as “the way things are done around here,” or simply the art of getting things done through the application of skills and knowledge [10]. This thesis will investigate the impact teaching engineers their broader role in meeting human need in the larger community will have on engineering education. Engineering education needs to change so that engineers will learn their role in human development; at the same time, educating engineers about their role in human development may improve engineering education. The former is the driving force, but the latter is an important consequence.

\(^2\)There are many context specific definitions for social justice, but in most cases it deals with the struggle to end different kinds of oppression, to create social and economic equity, and to restore relationships among all people and the environment. Donna Riley, in her book Engineering and Social Justice, presents many working definitions and describes several streams of social justice thoughts and actions [15].

\(^3\)The 2005 Queen’s University exit poll showed that only 29% of graduating engineering students said they obtained an awareness of social and political issues during their engineering education — this was significantly lower than the students from the other faculties.
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1.2 Human need and human development

The intent of this thesis is to investigate the possibility of educating engineering students about assisting others in meeting their human needs. The following pages will discuss many details behind this proposal, including the role of the engineer and an analysis of technology, development, and education, but what constitutes human needs must first be defined. Finding a definition is not trivial; human need has a different meaning for every individual, and all needs are not of equal importance, but exist in a hierarchy.4

Since the beginning of the 1970s, many United Nations and other development programs for low income communities have explicitly referred to a ‘basic needs’ approach [20]. Specifically, these basic human needs included safe water and sanitation, nutritious food, secure shelter, health care, clothing, an opportunity to learn about the world, and meaningful employment or livelihood.

Human needs go beyond these basics, however. The vulnerable in society, such as the children, the disabled, and the elderly, require a greater degree of protection. An additional human need which is identified by economist Amartya Sen (see his book, Development as Freedom [21], for example) is the opportunity to choose how to live one’s life. Paulo Freire also identifies that humans have needs beyond the physiological:

[The people] must realize that they are fighting not merely for freedom from hunger, but for freedom to create and to construct, to wonder and to venture.
Such freedom requires that the individual be active and responsible, not a slave or a well-fed cog in the machine [22].

For the purpose of this thesis, basic human needs are defined not only as the physiological needs to stay alive, but also the social needs of safety, belonging, and a degree of freedom. There is much discussion in the literature about the definition of human need5

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4 The psychologist, Abraham Maslow is known for his description of the hierarchy of needs.
5 See [20, 23] for an in depth discussion of human need.
and the role of development and humanitarian work. This thesis will research and discuss
the extent to which an engineer can and should assist others in meeting their needs.

Before the finer details can be presented, the following question must also be answered:
whose needs should be addressed by engineers? The scope of this project is any group
that is marginalized. Engineering for international development is an obvious connection
to make, as much attention has been given to the role of technology in the development of
low income countries, but there are national and local communities in great need as well.
Marginalized communities in Canada, for example, could include certain First Nations
reserves, schools in low income areas, or adults with physical or mental disabilities. There
is great human need as the result of natural disaster, poverty, war, hatred, and a plethora
of other sources, and there is no need to limit the scope of this project any further.

Like ‘human need,’ the word ‘development’ has also come to mean many things in
many contexts and can be quite ambiguous. Development can refer to physical human
growth, increase in economic growth or opportunity, or the increase in a built up environ-
ment and infrastructure. Denis Goulet says that the term ‘development’ is used to describe
both goals and the means for reaching them. Moreover, he says, “the practice [of develop-
ment] has oscillated from one-dimensional pursuit of economic growth to comprehensive
social engineering to transform social structures” [24].

In the case of this dissertation, development means simply improvement.6 Human de-
velopment refers to an improvement in living standards of the whole world population.
If some people are working to meet human need, they are working towards human de-
velopment only if the needs of others are not compromised. Human development is the
changing of all people to result in a more equitable, socially just world. (This may mean
the decline in living standards of some.) This term describes the role of the engineer quite
well: it brings together the provision of infrastructure and engineering solutions but also

6Because, etymologically, development means to unwrap and unveil, it has to be fundamentally about
persons and communities being more, not simply having more.
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social change. An engineer must consider both of these roles.

Human development is more important today than ever before, as the gap between the rich and the poor is wider than ever before. More than one billion people lack access to safe drinking water, and more than two billion lack basic sanitation.\(^7\) In addition, the lack of infrastructure and appropriate energy; soil nutrient depletion and desertification; global climate change and destabilization; increasing population, especially in urban slums; disease, war, and natural disasters (which always affect the poor the most) all add to what can be described as a growing crisis. This thesis considers a humanitarian engineering program as a beneficial way for engineers to respond to this crisis through educating their students about their role in meeting human need and in human development.

1.3 Humanitarian engineering

This thesis will discuss a proposed humanitarian engineering program for engineering education in Canada. Humanitarian engineering is defined as the application of engineering skills specifically for meeting the basic needs of all people, while at the same time promoting human (societal and cultural) development. It involves making the social consequences of technology the key constraint in the design procedure.

Humanitarian engineering is not simply another engineering discipline such as mechanical or civil engineering; it is a philosophy on how engineering is taught. Humanitarian engineering must transcend all engineering disciplines. In fact, it can be thought of in conjunction with any engineering discipline. For example, bio-mechanical engineering can be seen as a subset of mechanical engineering and software engineering can be seen as a subset of computer engineering, but the principles of humanitarian engineering are important for both bio-mechanical and software engineering, as well as mechanical and computer engineering. Humanitarian engineering, however, is no different than the

\(^7\)These statistics come from Target 7 of the United Nations Millennium Development Goals. See [13], for example.
many engineering disciplines in the sense that it requires a specific type of training and instruction.

In theory, all engineering should be humanitarian engineering. Engineers, by the very nature of their work, have a responsibility to society. In Section 1 of the Professional Engineers Act (Professional Engineers Ontario), professional engineering is defined as an act in which the “safeguarding of life, health, . . . or the public welfare is concerned” [25]. The engineering profession has a fundamental ethical responsibility. Despite this, the importance of public welfare in engineering is frequently forgotten or ignored and our academic institutions often focus primarily on the needs of corporations and industry [26].

It is important to note at this point that the proposed program is to be considered a hypothesis. The framework for the proposed program was prepared before data collection, but in no way am I assuming it is the right thing to do. I hope, as a result of the data analysis, to be able to either further design the program or to recommend against it.

The above initiative proposes work with faculty and staff to introduce humanitarian engineering concepts and ideas into the existing curriculum. The humanitarian engineering office may work with a heat transfer lecturer, for example, to include examples of heat transfer in emergency relief housing. In addition, new courses, case studies, seminars, projects, discussion groups and placements that deal with humanitarian engineering could potentially be added to the curriculum. A point of extreme importance must be made here: the intention behind all of the proposed additions to the engineering curriculum is not simply to add to the options available to the students, but to find a way for all students to be exposed to humanitarian engineering ideals.

It is not the point of this thesis to design the curriculum. A humanitarian engineering program will be proposed, but the syllabus of the program is not intended to be the focus of the thesis.
1.4 Motivation of research

The simple facts that over 30% of the world lacks clean water, adequate housing, proper sanitation, or nutritious food and that engineers have skills that can help alleviate these problems should create a convincing enough argument in favour of educating engineers about human development. However, there are additional, practical arguments that can be made.

One additional benefit is the influence this sort of education could have on the student. Higher education is much more satisfying when knowledge is connected to a social agenda [19]; humanitarian engineering can enhance student learning. Students will have an extra incentive to learn fluid dynamics, chemical kinetics, or heat transfer theory when they learn that it can be used to bring clean water into homes, develop biogas power generators, or design solar powered cook stoves. This enhancement will be even greater when students apply these skills.

The benefits go beyond the needy and the student; there could be advantages to the engineering community and society as well. Humanitarian engineering could result in more socially aware engineers. There is a strong feeling in professional engineering communities that engineers must use their hearts as well as their heads as they seek to meet the needs of people today. Future engineers must add a human element to the high-tech approach we see today. In turn, more socially aware engineers will improve the perceived role of the engineer in society.

Further more, the benefits could be experienced by the institution that would grant the degree as well. As mentioned earlier, many engineering faculties across Canada are struggling with a declining applicant pool [18]. If students can see that as engineers they can have a positive influence on people’s lives, they will be more likely to choose the engineering field. Humanitarian engineering can attract more quality students in a time when enrollment is suffering. Women and minorities are especially drawn to engineering
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Figure 1.1: The motivation for humanitarian engineering really comes from two distinct directions.

if it offers a humanitarian component [27].

Many universities are moving towards greater internationalization. In Fall 2005, for example, the principal of Queen’s University, Dr. Karen Hitchcock, wrote a discussion paper entitled ‘Engaging the World’. In this paper, Dr. Hitchcock stated that Queen’s must be committed to global engagement. This statement has been criticized for its alleged ambiguity; after all, global engagement can be done in both a positive and a negative manner. A humanitarian engineering program could help Queen’s and other Canadian universities engage the world in a positive way.

All of the motivations mentioned above can be summarized into two driving forces: people want to do something meaningful and desire to create strong community, as depicted in Figure 1.1.

There appear to be many benefits to a humanitarian engineering program, but this proposal must be critiqued and analysed. Why should we bother with humanitarian or human development work, either locally or internationally? How can a rich and comfortable Canadian engineer possibly do good when he or she does not understand the social-political environment of the marginalized? Does not charity or aid create a dependence in its recipients? Is doing nothing the easiest way to do no harm? There are many challenges in development work and there is great potential to do more damage than help; many in
the past, with noble intentions, have caused great damage [28]. Also, if done inappropriately, development work can seriously undermine a culture’s ability to care for themselves. Any proposal to introduce a humanitarian engineering component would need to address these potential pitfalls.

1.5 Research question

Thus, this research study will delve into the academic study of both engineering education and human development and look for places where the fields intersect. In doing so, the thesis will attempt to answer the following research question:

Is there a need or an opportunity to educate engineering students in Canada during their formal engineering education about their potential role in poverty reduction, disaster relief and human development? If so, what exactly is this role? What would the benefits and the limitations of such a change to the engineering curriculum be, and what could this curriculum look like?

This research question can be broken up into 6 ideas regarding humanitarian engineering:

1. The need
2. The opportunities
3. The role of the engineer
4. The benefits
5. The limitations
6. Implementation
The last point in the list above has a different nature than the previous five. As mentioned earlier, the goal of this thesis is not to design curriculum, but to make recommendations on the nature of the curriculum. This thesis has been motivated by a proposed Humanitarian Engineering program, and thus there are already some ideas on what that curriculum could look like. As a result of the research, a more refined curriculum can be described, if a curriculum change is indeed necessary. Thus, a program design is both a motivation (input) and an outcome (output) of the study, as suggested in Figure 1.2.

![Figure 1.2: Implementation: The program design is both an input and an output for the proposed research](image)

In some ways, this research question is not a new one. Much has been written about engineering education and the role of engineering in society. Academics have been calling for change in engineering for more socially responsible engineers since the very beginning of formal engineering education. The question is, however, new and necessary when it is posed in the current historical climate. This dissertation contributes by pulling from multiple disciplines, in order to speculate on the role of engineering for human development. Further contributions arise from practical suggestions for engineering education to specifically address marginalization and impoverishment in advanced, market-driven 21st century societies.

1.6 Thesis layout/overview

In order to answer the above questions, this dissertation is broken up into several sections, as shown in Figure 1.3. Chapter 2 and 3 give some necessary background information
and summarize some of the important literature. Specifically, Chapter 2 discusses the relationship between technology and development over the past decades. Chapter 3 looks at the evolution of engineering education, with a focus on the current state of the field. The research methods and methodologies are discussed in Chapter 4. The next chapters give the results and discussion of the data. Chapter 5 will present the data and analysis, while Chapter 6 will give a more detailed discussion of the analysis. Conclusions and future inquiry are given in Chapter 7.

Figure 1.3: This thesis is broken down into 7 Chapters.
Chapter 2

Technology and development

Any ordinary city, however small, is divided into two cities, one the city of the poor, the other of the rich, at war with one another. – Plato

All effort is insufficient, all glory transient, all solutions inadequate to the challenge, all aid insufficient to the need. – David Rieff

The whole pattern of globalization is not working as everyone assumed, in the more romanticized discussions, it would work. ... What we’ve learned, of course, is that globalization is intensifying the disparities among people and has caused us tremendous problems. – Stephen Lewis

From its very beginning, development has been conceived as involving technology for industrial and agricultural production and for physical infrastructure; in today’s cybernetic age, development is often associated with technical progress. In fact, the terms ‘development aid’ and ‘technical assistance’ were often, and still are today to a lesser extent, seen as synonymous. In many ways, the development industry has been primarily concerned with how to best create, transfer and apply modern technology. This chapter
2.1 A brief history of development and the engineer

The story of technology and development is one of power, conquest, growth, impoverishment, and change. In the pre-industrial era, much like today, humans struggled for power, tensions existed between the poor and the rich, and tools were created and manipulated. The difference was that change was extremely slow. Rapid change, on the other hand, began during the Industrial Revolution,\(^1\) which commenced sometime in the 18th century in Britain. But, as is always the case, the advantages and disadvantages of increased industrialization did not influence everyone equally. Subsequently, the divide between the rich and the poor also began to grow at an increasing rate. This divide grew within communities and countries, but also globally during the age of colonialization. There have always been the rich and the poor, but never in the past have the rich been as rich and the poor as desolate, as they are today \(^{30}\).

2.1.1 Post war reconstruction and decolonization

Traditionally, dealing with the poor and vulnerable was done at the community, clan, tribe, kingdom, or national level.\(^2\) International development work, often referred to as simply development, did not become an area of great interest or academic research until after

\(^1\)Economist J. Rogers and historian H. Gibbins delivered a lecture in 1888 suggesting that during the middle ages there was no such grinding and hopeless poverty or chronic semi-starvation in any class, as existed among large classes in the great cities of England in the early 19th century \(^{29}\).

\(^2\)The idea of working with the marginalized is an age old philosophy and can be seen in all major religions and ancient philosophies. Four thousand years ago, the Code of Hammurabi instructed the Babylonians to care for the widows, orphans, and poor.
CHAPTER 2. TECHNOLOGY AND DEVELOPMENT

World War II. The reconstruction of Europe and decolonialization of Africa, Asia, and Latin America in the 1950s and 1960s created a great surge in development work and a new way of viewing the relationships between richer and poorer nations [30].

The post WWII world saw the creation of several multilateral bodies for development, including the International Bank for Reconstruction and Development and the International Monetary Fund (IMF). The International Bank for Reconstruction and Development, now known as the World Bank, was intended to make loans to countries, underwriting private lenders, in order to encourage a speedy post-war recovery. The IMF, a fund that member countries paid into, was intended to provide short term loans designed to prevent deep debt and to create a more stable world economy. These institutions were designed to promote world trade, and their immediate focus was on war-torn Europe. Often called the Bretton Woods institutes because they were devised at a conference in Bretton Woods, New Hampshire (1944), these institutions were seen as revolutionary in their time, and it was anticipated that they would help prevent future conflicts by smoothing out temporary financial imbalances of debt and payment problems [31]. The institutions were built on Keynesian thought, which stressed a managed market and full employment for everyone.

In 1945, American president Franklin Delano Roosevelt made ‘freedom from want’ one of the ‘Four Freedoms’ on which he wished to see the post-war world constructed. The disparities between the wealthy and the poor were obvious after the war, and Roosevelt saw post-war order as a way to ensure continuing American prosperity. As the successful rebuilding of Europe progressed, the poverty of the colonies and the pending disorder came to the attention of the world as many colonies started their struggle for independence.

It is impossible to discuss the history of development without discussing technology. After all, there is a strong, direct correlation between the wealth of a country and its access to technology. The popular thought at the time was that if the lives of the poor were to

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3Named after John Maynard Keynes, an influential British economist.
be improved, it could be done by simply providing access to technology. In light of the West’s successful, post-war economic regeneration, US President Truman, in his inaugural address in January 1949, promised that the benefits of scientific advance and industrial progress would reach ‘underdeveloped areas’. For many historians, Truman’s ‘fair deal’ in his inaugural address marks the beginning of the age of development [32].

This growing awareness led to new academic fields of study such as developmental studies and development economics. The roots of the emerging fields were found in philosophers and economists such as Karl Marx, Wilhelm Hegel, and Adam Smith [33]. The ideologies of the European age of enlightenment, and the belief that the world could be transformed with scientific discovery and human intervention, were influential in these new academic fields. While much of these new fields were concerned with improving the standard of living in the so-called global South, the ideas were driven by the North with minimal contributions from the South.

The motivation for this new movement has been greatly debated. Many in positions of power argue that altruism and social justice are behind the great interest in international development, but many other motivators have been suggested, including global security and access to resources and markets. Perhaps the most important motivation for development was to spread ideologies. Post WWII saw two powerful ideologies come to dominate: Western market capitalism and Eastern communism. Both the Americans and Soviets were interested in being the dominant world power, and aid quickly poured into strategic countries in Europe and the rest of the world. American aid, for example, was focused on countries with Soviet influence in order to widen the U.S. sphere of influence. This quest for political leverage was often stated explicitly, as in the following example from a presentation given by the United States Agency for International Development (USAID).

4The story of the American CIA killing of the elected, left-leaning leader of the Congo, Patrice Lumumba, shortly after independence is an example of the struggle of the superpowers for influence and access to resources. The Americans then aided the notorious Sese Seko Mobutu, a staunch anticommunist, to power [34].
USAID has increasingly recognized that economic aid can promote development not simply by supplementing the host country’s limited capital and technical resources but also by exerting influence on host country policies and programmes. As we have become more aware of aid’s potential leverage role, we have experimented with techniques for exercising such leverage more effectively. [35].

2.1.2 The first decades of development

Many colonized countries began achieving independence in the 1950s and 1960s. Compared to the ruling colonial power, the occupied nations lacked industrialization. Under this power, the colonies did not require modern technologies, except perhaps for mining applications. Even for resource extraction, however, the most advanced extraction technology was not seen to be required because of the availability of cheap labour.

Upon decolonialization, the new governments were to undergo a complete paradigm shift: no longer to exist for the benefit of their former occupier, but for the benefit of their own people — albeit an arbitrarily defined group of people\(^5\) in many cases. The newly formed countries saw technology and industrialization as the path to prosperity and looked to the global North for help. Unfortunately, the power in most colonies was handed to a small group of local elite who were often disconnected from the bulk of the population and had grown up witnessing those in power living lives of wealth and comfort.

Inspired by Europe’s successful reconstruction, an attempt at modernization was seen as the solution for Africa, Latin America, and Southern Asia. Northern policy makers were

\(^5\)Sub-Saharan Africa, for example, was divided into regions by their European occupiers during the Berlin Conference in 1885. In some cases, tribal enemies were made to share the same country, and in other cases, certain clans were divided by a new border. Probably every single border in Africa divides at least one ethnic or cultural group.
quick to incorporate the merits of rapid modernization. In the late 1950s, American president John F. Kennedy optimistically called the 1960s the decade of development, thinking that the damage of colonization could be healed in 10 years [30]. It is now sometimes referred to as the first decade of development.

During the 1960s there was a sense of optimism in the development industry. Initially, the economic growth and agricultural yields were high — in some cases greater than those of industrialized nations [2]. But growing interest payments, dependence on monocrops for export, and growing populations made this growth unsustainable. In 1969, a report published by a commission headed by Lester B. Pearson acknowledged some major accomplishments, but warned about many other looming troubles: rising debt, growing urbanization, unsuitable technology, and malnutrition [36]. The Pearson Commission urged the industrial countries to make adjustments to allow for purchasing of manufactured goods from developing countries. The irony is that structural adjustments came to be imposed by the IMF on the South, rather than something required of industrialized countries in the North.

Coming into the 1970s, a sense of large scale technology and development was seen as the ideal. It was believed that previous failures were due to political and economic mistakes, and not to the inadequacy of the technology. Technology and development were necessary for industrialization, and industrialization was required for growth. Growth was seen as essential for developing nations to ‘catch up’ to the rest of the world. Even larger investment in highly capital intensive industries were typical in the early 1970s. The Brandt Commission, however, published a follow up report to the Pearson Report, suggesting that the attempts at rapid industrialization were destined for failure because of the inappropriately skilled labour force, the dependency on imported raw materials and spare parts, and the application of technology without attention to culture [37]. Even worse, high tariffs were added to processed and manufactured goods, while raw lumber and iron ore, for example, entered the North for free, ruining the potential to capitalize on
the expensive large scale development, mostly bought with high interest loans [2].

The lack of positive change in the first two decades of development also saw many people on all sides of the development paradigm growing disillusioned and distrustful. In the early 1970s, Paulo Freire, a Brazilian educator, started a movement through his call to the most marginalized to use their own creativity for liberation instead of waiting for development from outside [22]. A classically trained economist, E.F. Schumacher, changed his ideology after working in Burma and India and seeing much high-grade, modern equipment standing idle. Large-scale technologies, standard in the context of the North, require a vast amount of chemical, electrical, mechanical, and organizational supports not possible for application in the South. In his influential book, *Small is Beautiful*, Schumacher stressed the dangers of large scale industry, suggesting that it would worsen rural unemployment and increase urbanization in low income countries [38].

At this time, there was a switch by some to a basic needs approach to development, including many new UN programs [20]. In terms of technology for a low income community, Schumacher suggested that the most appropriate technology lies between the traditional and the more sophisticated that might be used in a high income country. This technology would do a much better job of being adapted and relieving poverty and providing employment than aid, he argued. He called this type of technology, intermediate technology, a term that later inspired the more common phrase appropriate technology [38].

The philosophy of appropriate technology (and *Small is Beautiful*) created division (and still does today) and many economists and practitioners have argued against it. Robert McNamara, a former president of the World Bank, argued that growth and production is the only way to address poverty. ‘In no one of these countries,’ he said, ‘can human needs be satisfied by the simple redistribution of existing income and wealth. In these countries, small is not beautiful’ [39]. The technology seen necessary for growth was roads, railways, irrigation and water systems, dams, factories, schools, and communication facilities. Despite the failing optimism, large scale projects continued to dominate the development
industry in the 1970s. Schumacher’s philosophy did have a lasting impression, though; even McNamara moved away from focusing only on economic growth and his mantra in the mid 1970s became ‘redistribution with growth’ [2].

The 1970s also saw the Green Revolution in Southern Asia, where mechanization, pesticides, and fertilization resulted in a great increase in food production. At the same time, however, this resulted in over-mechanization and increased populations — in fact, the population grew faster than the food production [40]. In 1974, at the World Food Conference in Rome, the US Secretary of State Henry Kissinger said,

   For the first time we may have the technical capacity to free mankind from the scourge of hunger. Therefore today we must proclaim a bold objective: that within a decade, no child will go to bed hungry, that no family will fear for its next day’s bread, and that no human being’s future will be stunted by malnutrition.

This did not happen by 1984; in fact, poverty and hunger in many parts of the world were more severe problems in 1984 than they were in 1974 [2]. Many authors have documented that the high-tech approach of the Green Revolution has done very little to help most small and medium-sized farmers, the land, or the consumers, compared to the wealth generated by the agrochemical industry [40, 41].

The close of the 1970s brought recession and a large concern for energy and the environment. The oil crises of that decade had a devastating impact on the poorest economies. Large, expensive and damaging hydro-electric and irrigation projects were under-performing [2]. The Brandt Commission suggested that most of the ‘benefits’ of technology, such as mechanization and fertilization, came at the expense of jobs, social harmony, and the environment and resulted in increased wealth to only the elite. The world of poverty reduction and development was far less optimistic at the end of the second decade of development than it was 20 years earlier [37].
2.1.3 Neoliberalism and the lost decade of development

The pessimism and lack of positive change around the world at the end of the 1970s did not result in an end to international development, however. In fact, development was a booming industry. Many government and intergovernmental institutions were founded; university study programs and development specialists began seeking funding and conducting research. It was believed that the failure of development was a result not of inaction, but of poor political decisions — there were too many restrictions on corporations. Bureaucracies that were established to end poverty by scientific means were stifling the growth of enterprises. Multinational corporations had limited success in poor countries in the 1970s because of political restrictions. Small-scale, intermediate technologies that had become popular in the 1970s were again criticized because they did not generate the necessary wealth and income.

The 1980s were the years that Ronald Reagan governed the U.S.A. and Margaret Thatcher governed Britain. Governments and corporations were failing to produce wealth, and Reagan and Thatcher both saw free market policies and privatization as an opportunity to increase affluence. They led a new economic change with a reduction in government intervention and a faith in the open market, often referred to as neoliberalism. Neoliberalism has its roots in economic theories coming out of the late 1960s, but took power in the early 1980s after several waves of inflation following the oil crises of the 1970s, and troubled economies converted to free market capitalism. As a result, technology transfer rested with Northern investors, whose primary concern for their investment was their own profit.

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6Neoliberalism is associated with fiscal discipline, tax reform to encourage spending, privatization, deregulation, property rights, trade liberalization and free trade, and foreign direct investment. These ideas would have been unheard of several decades earlier — social and political decisions were made based on the market and citizens were given less rather than more social protection. Susan George gives a thorough summary of the rise of neoliberalism.
In many ways, putting the economic power in the hands of the entrepreneur or corporation and not in the hands of the government agencies resulted in success. There was a significant increase in the sum total wealth, but there was a higher human price for the wealth as well. As wealth increased, so did exploitation and the loss of indigenous livelihood. The opening of the free market resulted in a decline in foreign assistance and an increase in third world loans. And as always, third world debt resulted in structural adjustment programs from the IMF. Structural adjustment plans dominated the policies of the IMF and World Bank during the 1980s, which greatly intensified the conditions placed on their loans. The structural adjustment plans were designed to promote economic growth and generate income by imposing free market programs and policies and discouraging government programs, even education and health. Often these policies crippled the traditional economic systems and, as a result, the gap between the rich and the poor grew much faster than ever before [2].

In a sense, at the beginning of the 1980s, the world was balanced with a variety of economic and political systems. Even free market capitalism was quite regulated in the U.S.A., but the rise of neoliberalism and the collapse of communism at the end of the 1980s was seen as a victory for the free market. The end of the Cold War brought a major shift in the power of the market in the debate against more socialist alternatives [42]. The dramatic shift in balance saw the race to spread ideology come to an end, and unpopular regimes were less supported both financially and emotionally by the super-powers. The West could now increase the conditions attached to its aid without fear of losing its third-world allies to communism [43]. Civil unrest and war surged. Nobody needed Sierra Leone anymore, for example, and the world essentially ignored its bloody civil war in the early 1990s [2].

As communism, as a dominant world ideology, came to an end, questions of development were suddenly no longer about systematic alternatives between capitalism and socialism, but rather about how to make capitalism work for poorer people. This led some
development theorists to criticize the whole notion of development as the project of Western hegemony.

During the decade of the 1980s, the debts of the developing world more than doubled. By the mid 1980s the money paid by the poor countries in interest payments exceeded the received aid and private lending [30]. For these reasons, the 1980s became known as the lost decade of development.

A final observation of the 1980s was the rise in popularity of non-governmental organizations (NGOs). NGOs rose in popularity because of dissatisfaction with the work of larger organizations and government aid and also because of the decline in official aid. In many ways, the rise of the NGOs occurred in conjunction with the rise of neoliberalism, as they both reflect ‘hands-off’ governing. It was a time where the free market offered no safety nets, and the NGOs could help on a very modest scale. Southern poverty was a growing concern among the populations in wealthier countries, and the private and non-governmental sector was seen as a promising mechanism to deliver aid. The concepts of intermediate and appropriate technology grew almost entirely from the non-governmental sector [2]. Organizations like World Vision, Care International, Plan International, Oxfam, and Médecins sans Frontières (Doctors without Borders) experienced tremendous growth in the 1980s and 1990s. Their strength was their ability to reach the poorest sectors of society, although others continued to argue that small-scale work was largely insignificant.

It was during the 1980s and 1990s that the appropriate technology movement took off. Engineers and other designers were tinkering with windmills, solar energy, latrines, and energy-efficient stoves. Bamboo pumps, low-maintenance bicycles, and small biogas plants began appearing everywhere.

2.1.4 Globalization and the new world order

By 1990, the number of poor had increased in both real and relative terms since the 1960s and a billion people were living in absolute poverty — spending most of what they earned
on food and still not eating enough [44]. The increased armed conflict and political violence that followed the Cold War were indicators of failed development. Political powers had fewer reasons to invest aid into other countries, and the world slipped into further imbalance. But again, this did not result in the end of international development. Global security, resource and market access, and the interest of the multinational corporations kept a foreign presence in the low-income countries.

The 1990s and the post Cold War world are best characterized by the rise in the globalization of markets, labour, and ideologies. The increased power of the corporation was seen in conjunction with the increased power of the World Bank and the IMF. As the free market gained power and tariffs were removed, official development assistance and aid dramatically declined and debt increased. Aid that was given was increasingly given to countries that could demonstrate the Western model of ‘good governance’ and democracy, which were suddenly seen as the requirement for development and not the outcome of it7 [43]. At this time, the World Bank and the IMF were seen by many to be more interested in creating profit than in global equity and their effectiveness was becoming increasingly debated. In their origins in post-war time, they were intended to help, but in many cases, during the age of globalization, it became clear that they had been acting in the interest of their largest shareholders, such as the USA8 [45]. As a result, the 1990s saw unprecedented growth, but also the wealth of the world falling into fewer hands.

Globalization also resulted in the spread of technology and information, and communication technology (ICT), which in turn resulted in wide-spread access to Western consumer culture. These trends have resulted in an increasing trust and faith in science, engineering, technology and innovation. In 1992, Maurice Strong, Secretary General for the U.N. Conference on Environment and Development, stated, “the concept of ... development would be impossible without the full input of engineers.” Science and technology policy

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7There is no evidence to suggest that democratic regimes experience greater economic growth. It is the character of the state and not the regime type that matters [43].

8Voting power within both the IMF and the World Bank is weighted according to financial contributions.
are seen as the path to development and wealth. Many developing countries have been quick to identify perceived benefits of technology, especially ICTs, for their development and poverty reduction [3].

In many ways, globalization is a phenomenon of extremes and paradoxes. For example, globalization has resulted in the extension of Western culture across the world, but has also resulted in the strengthening of cultural, ethnic, and tribal loyalties. Goods are produced with components produced all over the world, but there are growing movements to buy only food and products produced locally. It is easy to ‘chat’ with someone from across the world, but many people live alone and are lonely. In terms of quality of life, more people have access to a wider variety of goods, but many argue that their overall well being is deteriorating.  

In the case of development, the 1990s saw an increased interest in the role of the multinational corporation, but it also saw an economic trend where economists started dealing with the social dimensions of development, welfare economics, and non-market behaviours. Amartya Sen, for example, in his book Development as Freedom, proposes that the best model for development is through creating an expansion of capabilities and choices. He argues that access to the market must be balanced by other human concerns, such as those of the environment and the distribution of opportunities [21]. The dominant notion of development continued, however, to be based on market growth and the technology to support it. Richard Peet argued that this dominant discourse “results from one interpretation of one aspect of one people’s history. Yet this notion is universalized in contemporary neoliberalism as the proven solution to the social and economic problems of all countries” [47].

But globalization, while creating great wealth and other positive outcomes, is not working for the poor. Joseph Stiglitz, a former chief economist of the World Bank, says in his

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9This was well documented in a 2000 World Bank study that interviewed over 60,000 people from around the world who were living in poverty [46].
book *Globalization and its Discontents*\(^{10}\) that the promise of globalization has failed the poor [45]. Science and technology policy makers in low income countries are correct in that technology and ideas drive economic change, but the trickle down theory is not being experienced; wealth is not reaching the poorest or most marginalized people.\(^{11}\) Many multi-national corporations are larger than entire national economies, but as the corporations get richer, more people seem to fall into poverty.

Technological innovation is still considered by many to be the path to development. The UN Millennium Project Task Force on Science, Technology, and Innovation (published in 2005) states that “developing countries must have the courage to break with traditional approaches and explore the role of science, technology, and innovation in their development strategies” [13]. While the Millennium Project’s eight development goals, referred to as the Millennium Development Goals (MDGs), do not directly mention technology,\(^{12}\) the UN Task Force on Science, Technology, and Innovation suggests that nanotechnology, biotechnology (including genomics), material science and ICTs are necessary to achieve all of the eight MDGs, including halving the number of people in extreme poverty [13].

The apparent benefits of science and technology on the economy are published in many places throughout the open literature. Obviously, a healthy economy and adequate jobs are crucial, but a blind faith that science, technology and innovation will, by driving the economy, improve the living conditions for everyone is not warranted. Jeffrey Sachs, another well known economist who has written much on poverty and development, has suggested that technology must be used to drive the economy, but must also work at the community level to help with basic needs [14]. These two ideas are certainly related, especially in the

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\(^{10}\)This book gives a rare glimpse into the IMF and World Bank. Stiglitz does not argue that globalization should be abandoned, but drastically changed to make it more fair. In addition to petitioning for the poor, he also says that globalization is not good for the environment, the stability of the market, and global conflict.

\(^{11}\)Writer and film maker Avi Lewis suggests that the trickle down theory is in fact appropriately named — “only a trickle makes its way down” [48].

\(^{12}\)Target 18 of the MDGs is the only target that mentions technology. It states, “In cooperation with the private sector, make available the benefits of new technologies, especially information and communications technologies” [13].
sense that an important human need is to have meaningful livelihood or employment, but if the goal is to improve the lives of the most disadvantaged, Sachs argues that there must be a focus on the basic human needs.

While attention to a basic needs approach appears to be on the rise again, there has been a growing tendency to blame globalization for contributing to marginalization. The ‘Battle of Seattle,’ where thousands of activists protested at the 1999 World Trade Organization (WTO) meetings stimulated a rise in anti-globalization and anti-neoliberalism movements [49]. Maggie Black suggests that these protests in many ways are a result of the failure of development [30]. Similarly, the attacks on the World Trade Center in 2001 not only removed a symbol of western capitalism, but are also seen as dissatisfaction with the great world inequality [49]. Franklin questions whether those involved in the attacks would have chosen other ways of acting on their convictions if they had seen real prospects for peace and justice in their communities [10]. Terrorism, tighter government surveillance, and increasing levels of aid after September 11 again suggest that there is a rise in global tension as the struggle for power and policy change continues. With a backdrop of resource scarcity, peak oil, and global warming, energy intensive globalized economies and the promise of progress are under attack [30].

The history given above is brief and incomplete, but attempts to highlight the evolving attitudes about technology and development over the past half century. Table 2.1 lists some of the important events. Understanding all of the nuances would require a great deal more description, but one thing that is known for certain is that the number of people living in poverty has continued to grow since the 1960s. The number of people living in poverty today is greater than the total number of people who lived on planet Earth at the beginning of the first decade of development. Even worse, poor countries that have received a lot of aid are almost indistinguishable from those that received very little [50]. In many ways, if the goal of development was in fact to ease large-scale human suffering, the 60 years of international development history would be described as 60 years of failure.
2.2 Technology and development today

In light of the history of development, it is easy to be pessimistic about the future of development work. Today, we have the benefit of looking back on 60 years of history — we know that dealing with poverty is not easy. So what can be done and is there a role for technology and engineers?

Poverty has existed from time immemorial, but it is not so much a question of reducing poverty as of attempting to halt its spread. Understanding the sometimes shameful history of development and listening to the complex debate are the first, and easiest, steps for engineering students — engineers have been a part of this troubling history. Studying the history of development and technology should allow one to learn more about human nature. A better understanding of this history can also prevent similar mistakes from being made again. Hubris continues to plague the development industry, and we need to understand this history before further attempts to ‘help’ are made. Upon better understanding history lessons, we must also fight the temptation to blame the current problems on the past without deep contemplation on how to proceed.
The following section briefly discusses current theory and practice. Through the presentation of this material, it is desired that an appropriate response for engineers can be identified, or at least that the thought process be initiated.

### 2.2.1 Development theory

The following section will give a quick overview of the most important development theories held today. There are others that are not mentioned here, but the five listed below cover the thinking from most prominent development theorists.\(^\text{13}\) Once these theories are understood, one can understand the benefits and concerns with different approaches to development and is in better shape to design curriculum with a human development aspect.

1. Modernization Theory
2. Underdevelopment Theory
3. Neo-Marxist Theory
4. Post Colonial Theory
5. Neoliberalist Theory

The *Modernization Theory*, which was dominant in the 1950s, is still very prevalent today. It is characterized by the notion of linear progress: development can be achieved through following the processes of development that were used by the current developed countries through various stages of economic growth [51]. Modernization Theory places education and the most sophisticated technology, especially information and communication technology (ICT), as important elements of helping undeveloped countries progress through the stages of growth [52]. A key factor in this theory is that developed countries

\(^{13}\)Richard Peet’s book, *Theories of Development* [47], is a good place to look for a more thorough survey.
should provide aid and technical assistance because they have already achieved a higher level of development and ultimately a place of equal development will be reached.

In development dialogue, there is much discussion about breaking down the ‘digital divide,’ the gap between the people who have access to ICTs and those who do not. Modernization Theory suggests that providing low income communities access to laptops, cell phones, and the Internet, for example, is an important step in dealing with the global digital divide [3]. The One Laptop Per Child (OLPC) program is an example of a not-for-profit organization trying to provide this technology through making a $100 laptop for impoverished children [53].

Underdevelopment Theory emerged as a critique of modernization. Instead of every country moving forward towards a certain stage of economic development, the Underdevelopment Theory states that the global South is constantly being exploited under the guise of development. European development depended on the active disorganization of its colonies and demanded a new division of labour through policy or military intervention. Even as central Southern cities grew, peripheral societies underdeveloped as capable workers left the agrarian communities [54]. The benefits of capitalism were constantly being drawn towards the centre and thus the regions with the strongest ties to the past became the most underdeveloped.

A common sentiment suggests that the developing nations are poor because the North is rich. Thus, the Underdevelopment Theory calls for changes in trade rules, international interactions, and third world solidarity. Unlike the common ideals of the Green Revolution for large scale industrial farming, the Underdevelopment theorists call for crop diversification and mixed farming. The concept of integrated rural development came out of this thinking, where focus was placed on the most marginalized in the periphery, and evolved at approximately the same time as organizations started talking about basic needs approaches. Robert Chamber’s influential book Rural Development has a subtitle, Putting
the Last First, and stresses how the farther one goes from the urban core towards the periphery, the more marginalized the people are [55]. Another term often used to describe development that reverses the top down approach is participatory action or participatory rural appraisal [56], and encourages complete immersion in a developing community.

Marxist and Neo-marxist Theories have elements of both of the previous theories. In some ways, Neo-Marxist thought is a modernist view that works towards progress, but also sees that development leads to underdevelopment. Neo-marxist theories stress that the material benefits from hard work and increased productivity are unequally distributed and that development must be done in a way that ensures fair relationships between classes [47]. They call for the development process to be rationally controlled through social means. Development and capitalism come with the price of environmental destruction and dependency, and thus Neo-Marxist thought calls for production that involves less dependency, which includes breaking ties with developed nations, pursuing internal growth, and focusing on indigenous technologies [57]. Creating self-sufficiency addresses the common criticism that development undermines a culture’s ability to care for itself and demand good governance.

Between the mid-1960s and the 1980s, Marxist theories dominated critical thinking about development. The failure of the Soviet Union, however, has led to some criticism of these theories: on one hand, Marxist thought was seen to have been proven inferior to capitalism and modernization, but others suggested that the problems lay in the very structured modes of production [47].

The Post-Colonial Theory, much like the Underdevelopment Theory, rejects the idea of modernity and finds its origins in a romantic celebration and rebirth of indigenous knowledge. This theory comes out of a Post-Structural and Post-Modern view of the world which rejects the notion of progress and order. The prefix ‘post’ designates a movement beyond colonialism and a new third world struggle for identity; post-colonialism is characterized

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14Progress in this case is in terms of when labour and class is divided in an optimal way.
by a radical reconsideration of the knowledge and identity that came out of colonialism and Western dominance. Modernity, which under colonial rule was seen as automatically good, became seen as a tool of Western hegemony. Post-Colonialism states that each community should control how its culture evolves.

Gandhi is a popular symbol of post-colonial thought, and his technology was simple and indigenous. Edward Said’s notion of Orientalism, the antagonistic view of the East by the West shaped out of imperialist attitudes and manifested through literature and art [58], was described in a book published in 1978 and reinforced growing post-colonial sentiments. The Post-Colonial Theory of development is sometimes criticized because of an excessive focus on national identity, but it remains popular amongst those who see development as trying to understand and revitalize traditional knowledge systems.

Neoliberal development theory, already discussed in Section 2.1.3, is much like the Modernization Theory, but includes a large focus on market access, economic growth and free trade. The thinking with this theory is that the economy will solve the necessary development problems and developmental failures can be blamed on the lack of appropriate market access. The World Bank, IMF, WTO, and many Western governments, including Canada’s, are considered to be neoliberalist institutions.

2.2.2 Post-development

Typical of this globalized age, a real dichotomy exists in the development industry: Modernization and Neoliberalism on the right and a small scale, participatory approach on the left. A third approach, easily extended from dependency, underdevelopment, and post-colonial ideas is one of post-development. Post-Development Theory concludes that the best way to ‘develop’ underdeveloped areas is to withdraw all elements of Western culture, as development is often about imposing views. In this theory, the development industry, along with the IMF and the free market, are seen as new imperialists.

The idea of development which once inspired such optimism is under significant attack
Peet quotes Mexican activist and author Gustavo Esteva, who says, “In Mexico, you must be either numb or very rich if you fail to notice that ‘development’ stinks” [47]. Today, despite all of the donations, more money is leaving Africa than is arriving due to debt and interest payments [59]. This does not include the skilled workers and the vast amount of resources that leave Africa.

In his book *Encountering Development*, Escobar suggests that the trend towards a post-development era comes from an interest “not in development alternatives, but in alternatives to development,” that is, the rejection of the entire paradigm altogether [32]. Ivan Illlich, in his essay *Development as Planned Poverty*, describes development as something controlled by the rich for the benefit of the most powerful, and calls for fundamental lifestyle alternatives [60]. Similar opinions were expressed in a speech he gave to a group of university students interested in a summer development placement:

If you have any sense of responsibility at all, stay with your riots here at home. Work for the coming elections: You will know what you are doing, why you are doing it, and how to communicate with those to whom you speak. And you will know when you fail. If you insist on working with the poor, if this is your vocation, then at least work among the poor who can tell you to go to hell [61].

Post-development thinking, as described in *The Post-Development Reader*, is often thought of in terms of acting and thinking locally, political opposition, and grass-roots activism. Also, simple living ideals suggest that happiness does not have to come from consuming,15 and that non-capitalist societies need to be reappraised — the non-developed world had not been so bad after all [63, 64].

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15Post-development thinking is not so far from the musings of Albert Einstein several decades earlier: “I am strongly drawn to the simple life and am often oppressed by the feeling that I am engrossing an unnecessary amount of the labour of my fellow-men. I regard class differences as contrary to justice, and, in the last resort, based on force. I also consider that plain living is good for everybody, physically and mentally” [62].
So, is doing nothing an option? Exploitation continues, and the needs are great. Post-development theory is often criticized for denying the fact that so many of its supporters live in luxurious centres of Western Modernity while romanticizing about indigenous peoples [47]. Sen argues that there is a danger in throwing away the goal of development and that there is life in the traditional analysis [21]. In his book *States of Development: On the Primacy of Politics in Development*, Leftwich suggests that post-development is naive as it aims to take control away from the central government and international agencies. He says that grass-roots movements are prone to self-destruction and that successful development requires strong politics, which in turn, joins various ideas, preferences and interests [43]. Sally Matthews, speaking from the African perspective, claims that ‘if we abandon the post WWII development project, what is it that is to guide our attempts to better our lives, to alleviate suffering and to structure our societies so as to eliminate poverty and inequality?’ [65].

### 2.2.3 Engineering and development practitioners

While from an academic perspective, there is reason to believe that the notion of development is dying, this is far from true in practice.\(^{16}\) The monopoly on development work held by governmental agencies has weakened, but the role of inter-governmental organizations such as the United Nations, multi-national corporations and non-governmental agencies has dramatically increased [66].

Over the past decade, the number and size of development NGOs has increased dramatically, and it is now a multi-billion dollar industry [67]. Many organizations still look to do development work, and many eager participants, often youth, look for cross-cultural experiences. While on the ground development is initiated by both government

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\(^{16}\)In development, practitioners often sit in opposition to scholars [55].
and NGOs, it is the NGO sector that is experiencing significant growth. Another advantage of the NGO is that while development from governmental agencies is ultimately influenced by Western neoliberal policies, private donors can pick an organization which matches their desired cause, although many NGOs are accountable to state policy as governments funnel official development aid (ODA) through them.

With large scale development left to governments, inter-government, and multinational corporations, many development NGOs excel at advocacy and participatory models of development [68]. Local accountability, reaching important constituencies, and awareness-raising are also seen as their strengths. While development NGOs are numerous and have no unifying objectives, their grassroots approach may give them an opportunity to better understand people’s expectations and needs, especially at the periphery, where governments rarely go.

The private sector is often criticized by some because it lacks accountability, is highly localized, and is often transitory [66], and by others because it still creates many of the same problems as larger scale development, such as dependency and underdevelopment, and it still reflects Western, neoliberal hegemony [67]. Robbins adds that current development practitioners work with implicit assumptions rather than engaging with the more complex understandings of development [42]. Many NGOs are staffed by generalists whose success depends much more on the quality of their fund-raising and marketing than on the success of their projects thousands of kilometres away from the support base. Some of these NGOs ‘win’ their support with a sentiment that ‘development is very difficult and potentially damaging, but we have the right formula.’ Sam Vaknin acknowledges the huge variation in quality in the NGOs, but despite their many problems is not willing to discredit them completely:

NGOs are on the verge of providing a ruinous backlash against themselves

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17 NGOs often have their area of expertise, be it education, women’s rights, drilling wells, or food processing.
18 It is estimated that there are approximately 50,000 NGOs working in South Africa alone [68].
in their countries of destination. That would be a pity. Some of them are doing indispensable work. If only they were a wee more sensitive and somewhat less ostentatious [69].

As long as there is a perceived need for external help and there are donors willing to keep the NGOs in business, and as long as there are practitioners who are willing to travel, development through this sector will continue. But there is a growing demand for more meaningful participation and deeper empowerment. Calls for greater humility, immersion, and a willingness to work with a community over many years are becoming more audible [70]. This is critical as more and more youth look to be involved with participatory development.

Engineers are increasingly drawn to this field. How can they use their skill to reduce poverty through development work? The engineer’s role in development for the first decades of development was in the design of large scale technology with little concern for the social conditions in which the technology was used. During the 1970s and the return to the basic needs approach from the 1990s to present day, however, the role of the engineer was more focused on appropriate technology\footnote{There has been much discussion about this term. Some people see appropriate technology as second rate or even obsolete technology. Of course, all technology should be \textit{appropriate}, but the point is that the technology for one community may not be appropriate for another community and that appropriate technology has been designed with the end user in mind.} for basic needs. In some sense, engineers are very good candidates to do development work. Much of the lack of basic needs in the world is related to infrastructure and services connected to engineering work. In a recent study on the role of engineering for poverty reduction, engineers Singleton and Hahn conclude that “Engineering solutions are integral to the mitigation of poverty”[71].

There are several NGOs that focus on engineering skills such as Engineers without Borders (EWB), Engineers for World Health, Engineers for a Sustainable World (ESW) and
In addition, all major NGOs have significant engineering contingents (World Vision, Care, Plan, Oxfam, for example). Engineering focused NGOs often deal with participatory projects, capacity building and applications of appropriate technology. Engineers without Borders, for example, focuses on working at the village level with sustainable technologies to build local capacity [73]. Disaster and conflict response is an important subset of humanitarian engineering. Fred Cuny, often regarded as one of the first humanitarian engineers, worked with many development agencies after growing dissatisfied with his engineering job in the 1960s [74]. He is well known for using his engineering skills in relief scenarios where engineering is often an afterthought. (He describes temporary homes for displaced people built with corrugated steel structures that get hot enough to bake bread [74]. )

### 2.2.4 Appropriate technology

As mentioned earlier, engineers make very good candidates to do development work. They are trained to find solutions to problems, and development work offers many problems. Technical skills have long been identified as key skills for poverty relief, but engineers are trained to be efficient and swift, and they are often seen to neglect the social and cultural impact of their technology [17]. Development engineers must be capable of good technical solutions while taking culture and societies seriously [75].

Following WWII, technology, development and modernization were seen as synonymous. The large scale dam for power, water, and food (irrigation) was the iconic technology for development during the 1950s and 1960s and often the technology was not seen in its economic, social, or cultural context [2]. Applications of technology at the community level and ‘technology with a human face’\(^{21}\) are more dominant approaches to the application of technology for development today, although the idea of technology as the solution is

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\(^{20}\) While the acronym ‘REDR’ stands for Register of Engineers for Disaster Relief, they are also involved heavily in development work [72].

\(^{21}\) A phrase coined by Schumacher [38].
not dead. Great claims are being made for the role of the information and communication
technology (ICT) sector, (especially the cell phone) in poverty alleviation [75]. But many,
including Moodley, suggest that these benefits are being exaggerated and take away from
resources that could better go elsewhere [3]. Despite all of the developments in this aca-
demic field, there remains a dichotomy between those who see technology as a problem
and those who see technology as a solution; between those who want high-tech, wealth-
generating solutions and those who want low-tech, participatory solutions.

This tension mirrors the entire story of international development and the need for
balance. Like in so many situations, there is truth in both extremes [47]. It is agreed to-
day, however, that technology development must be embedded in economic, social, and
cultural relations.

While the high-tech versus low-tech issue is a classic development debate, the emerg-
ing paradigm is to use small-scale solutions suited to local needs, resources, capabilities,
and skills. The goal here is to re-empower the community without the interference of out-
side influences, keeping in mind that empowerment cannot be given, but is something
that the community must take on its own. Amartya Sen says that the only thing that can
be done is to create an environment facilitating this process [21]. This emerging paradigm
requires engineering to produce technology, with a full understanding of the power and
knowledge associated with machination. This calls for appropriate technology, which does
not necessarily mean small or low-tech.

Latrines, hand pumps, windmills, and biogas digesters have long been the icon of ap-
propriate technology – their success is well chronicled – but there are many technologies
that can be associated with appropriate technology:

1. Urban and rural housing, shelter, and building materials

2. Urban and rural water supplies and treatment

3. Irrigation
4. Health and sanitation technologies (Sand filter for example)

5. Solar desalination

6. Energy and fuel supplies (and the necessary environmental protection)

7. Waste management and recycling (Composite materials with waste plastic for example)

8. Crop harvesting

9. Post harvest food processors (Solar dryers, palm oil extractors, or cassava graters for example)

10. Cook stoves (designed to use less wood or charcoal), solar cookers

11. Human mobility devices

12. Rural electrification

13. Crank radios

While there have been success stories, many attempts at creating appropriate technology have been complete failures, which leads to the question: Who decides if a technology is appropriate? If developed by an outsider, appropriate technology must be developed for a specific community, a process which requires time and humility in order to understand the community. Smillie says that “the notion that technology can be transferred without modification has few historical precedents to support it” [2].

In his essay on technology transfer, Jens Müller says that technologies have always been transferred from one society to another, but that each community should make these decisions for itself. He says there are three scenarios in which technology transfer can happen:
1. The technology being supplied is fully adapted to the social setting of the receiver

2. The social setting of the receiver is fully adapted to fit the technology supplied

3. Both the technology supplied and the social setting of the receiver are changed to fit each other at some point, which can hardly be pre-determined.

Scenario 3 is, of course, the dominant path, as there is no clear-cut recipe. Müller adds that in most cases, the most appropriate technology will likely have already been developed in the community, by the community [76]. The appropriate technology movement has admirable beginnings in response to irresponsible large scale technology, but it still rests on the assumption that a technical fix may be found; progress and development in the Third World simply requires that we get the technology right. Sue Ellen Charlton argues that “to be fully appropriate, a technology should ideally grow from within a society and reflect local choices” [77].

To help make this point, two situations where local concerns were not considered are presented. First, in his book, *Rural Development*, Robert Chambers describes the installation of a Rice Mill in a South Asian country that greatly improves the milling out-turn efficiency and benefit-cost ratios. What is not calculated is the loss of work and the loss of a social activity [55]. A second example comes from Janelid, as cited in Charlton:

For generations, the extraction of oil-palm fruits, a time and energy consuming task, has been done by women in some Nigerian communities. ... When the oil press had been installed, 72 percent of the people used it, but after a year the figure dropped to 24 percent. Although they knew about the benefits, they withdrew from the use of the oil press for several reasons — the by-products of the pressing pit were lost; the daily time schedule for using the oil press did not coincide with that of the women; the size of the mortar was designed for men, and women could only use it with an increased labour force; during the peak
season, the women had to wait for the use of the press; all oil from it belongs to the men, and the women did not benefit from the increase of oil per unit of fruit processed [77].

Stories are useful in understanding the complexity of development, but one can never have the full picture. Positive lessons can be learned from failed projects, but there is no formula for successful development. For many years development was seen as the magic formula, but as Escobar points out: “the voices that are calling for an end to development are becoming more numerous and audible” [32]. Successful development will always be something of a grail quest. Moving to a post-development era has been suggested, but the poverty crisis must be addressed.

This dissertation is about the role engineers have — if any — in development. Engineers, attracted to technical problems, of which the developing world has many, have always been at the centre of development, but engineers in development cannot simply be bringing more technology or wealth to poor countries. Development should also not be seen as only helping others; it must be about improvement and social justice and must be for all people. Maggie Black says,

There can be no recipe for development, only many potential recipes for different contexts. ... But true development is about people, and social beings do not function mechanistically. There is no common prescription. To be of genuine use to people, development has to grow organically, building on existing knowledge and systems, and engaging empathetically with modern ideas. Is this really so impossible? [30]
Chapter 3

Changing engineering education

Academic chairs are many, but wise and noble teachers are few; lecture rooms are numerous and large, but the number of young people who genuinely thirst after truth and justice is small. – Albert Einstein

Towards what ultimate point is society tending by its industrial progress? When the progress ceases, in what condition are we to expect that it will leave mankind? – John Stuart Mills

When needed, my skill and knowledge shall be given without reservation for the public good. From special capacity springs the obligation to use it in the service of the public; and I accept the challenge and all that it implies. – Engineering Institute of Canada

The previous chapter presented the history of the role of technology in international and human development. The goal of this chapter is to continue laying out the background and historical context of this thesis, but this time in terms of engineering education.
While engineers have been involved in development since the time of Truman, post-WWII, it is only very recently that issues related to development have reached the engineering curriculum. For most of the years of development, the technology developed by the engineers was simply required to be transferred from one setting to another; explicit instruction about development was not necessary, because designing a hydro-electric dam or a seed oil press for Canada, for example, was essentially the same as designing these devices for Latin America. Engineers were to design the device, and development practitioners were to figure out the transfer. Recent trends, however, suggest that since engineering is such an important part of human development and that technology transfer is not as intuitive as initially thought, there should be room in the engineering curriculum for development dialogue [71, 78, 79, 80].

It is desired that this historical background will help one understand the dynamic evolution of engineering education, and better prepare the reader to look critically at the current situation. The title of this chapter refers to the need for continued change in engineering education. A historical account is a necessary prerequisite to discuss a proposed plan for the future. Once a historical context has been presented, it will be possible to further investigate the potential of teaching engineering students more about human development.

### 3.1 A brief history of engineering education

Linguistically, the term *engineer* is a comparatively recent word. It is believed to have been first used during the middle ages to refer to the designers and builders of military structures and devices. Ironically, the roots of the word are often traced to two subtly different Latin words — *ingenium* and *ingeniare* [81]. Ingenium, a noun, refers to mental power, ability, or a clever invention; ingeniare, a verb, means to devise, and is more closely related to the creative process. To this day, there is a tension between the role of analytical thought versus creative ability within the engineering discipline.
Engineering education attempts to train men and women in the art and science of engineering. This section traces the changing role of engineering education as educators strived to find the right balance in light of the historical, cultural, and political environment.

### 3.1.1 The beginning of engineering education

Samuel Florman, a well known engineer and author, defines engineering as the art and science of making practical application of the knowledge of pure science [82]. Nothing in that definition suggests any sort of formal training, and indeed, for most of history, scientific knowledge was applied intuitively and was gained through experience rather than through academic channels. Obviously ancient civilizations depended on creative designers and builders, but we know very little about their training. The engineer did not need to have a formal education in science; the necessary information could be acquired through actual practice and word of mouth, perhaps in a master/apprentice type relationship.\(^1\)

Another reason we know very little about the formal training of engineers is that the engineering profession was seen as inferior to vocations such as business, law, and politics. Technology was seen to be unworthy of mention, even positively distasteful. In many early civilizations, the cultural and economic elite regarded manual labour as suitable for the lowest and slaves. As Aristotle said, “No man can practice virtue who is living the life of a mechanic” [81]. The Medieval and Renaissance periods saw an intense interest in classical learning, such as philosophy, theology, law, and medicine, but the gulf between the humanities (knowledge) on the one hand and science and technology (craft) on the other remained until around the 18th century.\(^2\)

Because warfare has always been a part of human history, the earliest engineers were, no doubt, military engineers who worked on both defensive and offensive machines. The

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\(^{1}\)The engineer still does not need to have a formal education, although in most places, a formal education is required before someone can legally work as an engineer, or even refer to themselves as an engineer.

\(^{2}\)This change, of course, coincided with the rise of the Scientific Revolution and the Enlightenment.
word engineer initially simply meant military engineer. While today there is more to engineering than combat, much of our modern engineering knowledge comes from the demands of the military. For example, the study of ballistics was the driving force for the development of the mathematics of motion. Another example: due to the great expense of nuclear power, it has been suggested that nuclear power plants would not have been developed without the rush to advance nuclear weapons during WWII [83].

Formal engineering education is also the result of military need. Due to its geographic location and the constant threat of invasion, France led the way with the world’s first engineering schools. It is difficult to isolate the exact date of the first engineering school as technical training for military officers slowly migrated from the field to the classroom. Perhaps the first school was École des Ponts et Chaussées set up in 1747, when the authority was given by King Louis XV to begin a government-run school of engineering to assist in the construction of a vast network of national highways [84]. By the end of the 1700s, the best engineers and best engineering schools in the world were French. As engineering was controlled by the French government, the most significant engineering advances were directed toward military purposes.

The late 18th century saw the increased use of engineering for improving industry and commerce.\(^3\) Engineering for developing the civilian infrastructure came to be called Civil Engineering and initially meant engineering for non-military purposes. French military engineers were occasionally assigned to civilian projects to strengthen internal communication for commercial reasons. In the meantime, the threat of invasion across the English Channel was smaller, and as a result the British were able to focus on exploring and industry. Thus it is no surprise that the industrial revolution came out of England [81]. This further drove the evolution of engineering into the service of industry and commercial

\(^3\)The implications of the increased industrialization are often considered to be favourable in most engineering texts, especially when compared to technology for combat. While many important and beneficial consequences occurred as a result of industrialization, it is essential to remember that many negative repercussions resulted as well. Much is written about these (see [85] for example), but the majority of this writing comes from sociologists and historians, and not engineers.
development, and resulted in significant wealth through industrialization.

While the growth of engineering education in France was fostered and organized by the central government, in England it was individualistic and unregulated. English engineers were trained primarily through apprenticeships and comradeships. Young men would work with practicing engineers to learn the necessary skills. Even though an engineering school was set up in 1796 in Glasgow and in 1800 in London, very few English engineers were university graduates until the late 19th century. It was through the movement away from craft-based industry towards mass production that higher education became the accepted means for engineering training.

3.1.2 Engineering education in North America

The history of engineering education in North America begins in the early 19th century and is closely tied to political, economic, and geographic forces. In turn, engineering in America combined elements from both the French and British styles; the French expertise in military engineering and the British skills for industrialization were both coveted. The US Military Academy (USMA), established at West Point in 1802 and modelled after the French, trained the first American engineering students [84]. French military engineers were recruited for instruction, and a knowledge of the French language was necessary. At the same time, labour was expensive and the country was vast; the American people required the rapid development of labour-saving devices, and infrastructure like canals and railways in order to expand.

For many years, though, USMA was the only school of engineering and its students and graduates were the only technically trained leaders of the rapidly expanding young

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4The evolution of formal engineering education can be described from many perspectives. Because my research question concerns education in Canada, the focus in this brief historical depiction is on developments in North America. There are important and interesting developments that have occurred in Australia, China, Germany, Italy, Japan, and many other places that will not be included in this section. These omissions are intentional for the sake of brevity, and not because I deem the developments elsewhere to be unimportant. See [81] for a more thorough history of engineering education.
nation. But as in many parts of Europe, formal engineering education was not seen as very important; it was too pragmatic and utilitarian for higher learning. It was predominantly thought that engineering was to be learned through experience instead of formal training [86]. The university of the early American nation was intended for religious, moral, intellectual, and spiritual development and included courses in literature, philosophy, law, and theology [1].

It was not until the mid 1820s that the first non-military engineering institution was developed: Rensselaer Polytechnic Institute (RPI). The US needed railroads, roads, and bridges, and the people behind the formation of RPI were prepared to train engineers to build them, even if the older institutions were unwilling. The formation of RPI occurred in an atmosphere of enthusiasm, expectancy, endeavour, and hope, and slowly the role of the universities in America began to change from a place concerned primarily with the building of the individual to a place concerned with the building of a nation. Slowly more universities began to teach engineering courses, even though many were opposed to the idea of ‘technical people’ at the university [86]. Harvard, after many years in operation, eventually graduated its first engineers in 1854. Another dramatic change occurred when Massachusetts Institute of Technology opened in 1861 to be a centre of scientific investigation.

By 1866, only approximately 300 engineers had graduated from schools other than USMA at West Point, as most practitioners were learning the necessary engineering skills through on-the-job experience [86]. The end of the American Civil War saw increased industrialization and economic growth while engineering education experienced a time of rapid growth. This period in the mid 19th century is sometimes seen as the beginning of the ‘Golden Age of Engineering’ [82]. For most of America’s history, labour was in short supply, but the abolition of slavery following the US Civil War put labour in even greater demand. This led to the creation of many labour saving devices [87], which in turn led to

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5Harvard was founded in 1636.
increased machine production, and an increased demand for engineers.

Engineering education in Canada developed in a similar manner, but at a slower rate than in the US, in part because of closer connections to Europe and also because of the tension that existed between the British and the French in Canada. Eventually, the need to develop the sparse and spread out country with railways and canals drove the need for engineers. Engineers were trained at King’s College (established in 1854 and later renamed University of New Brunswick), McGill (1857), École Polytechnique (1867), and the University of Toronto (1878).

The turn of the century brought the development of the automobile and airplane, the growing need for oil and electric power, increased techniques of mass production, and increased urbanization. The first quarter of the 20th century saw universities operate in support of industry like never seen before. David Noble suggests that this move to increase the relationship between the university and business marks the end of the free pursuit of knowledge. The pursuit of knowledge, he says, gained more social and financial support, but it would no longer be free.

3.1.3 Engineering education and the World Wars

The time of the World Wars and great depression, especially WWII, had a dramatic transformative effect on universities and engineering education. Schools in North America quickly adjusted themselves to be of service to the state. Many students and professors enlisted in the military, and engineering facilities were used for barracks and for conducting war-related research. The time of the World Wars also saw the establishment of new federal research granting agencies [1] as the governments of both Canada and USA looked to conduct research on weapons, communication, aircrafts, fuels, surveying and mapping.

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6It could be argued that for much of the 19th century, the American university had operated against industry [2].
explosives, and materials. Prior to the two World Wars, engineering focus was on industrial practices, but the engineering science research focus seen during the World Wars changed the face of engineering education forever.

After WWI, engineering experienced another increase in interest. Demands for graduates with immediate utility for industrialization and economic growth forced more specializations and the number of academic disciplines expanded. The depression of the 1930s brought about a new concern for the social role of engineering. This economic hardship brought about a growing awareness of the often negative influence of technology on society. In the 1937 Proceedings of the SPEE,\textsuperscript{7} Whitehead writes,

I do not believe that our Society can continue to tolerate highly trained engineers whose interest is exclusively centered in the details of their mechanisms ... Unless we can train engineers whose interests in the vital social processes is comparable to their technical interests, I fear that we engineers may be paving the way for a companion volume to Gibbons’ ‘The Decline and Fall of the Roman Empire.’ [89]

When a second World War broke out, attention shifted again to the war effort, and nearly every engineering education institute supported the war by placing their facilities at the disposal of the government, even though it considerably disrupted their normal operations. WWII was a time of tremendous scientific growth. Aircraft structures, plastics, radar, sonar, projectile motion, numerical analysis, microwave applications, new lubricants, electronics, and metallurgical discoveries were only some of the advancements that experienced rapid development because of the increased funding and pressure for the war efforts [86].

The increased research funding during WWII carried over after the war and sparked tension between those who thought the university should focus on teaching and those

\textsuperscript{7}Summer Institute on Effective Teaching for Engineering Teacher — later renamed the American Society for Engineering Education (ASEE).
who saw value in an expanded research focus [86]. While this tension has existed ever since, the balance between teaching and research heavily favoured research after the war, as science and engineering were seen as the ‘Endless Frontier’ for health, prosperity, and achievement [1].

As thousands of veterans returned to North America, eager to resume or begin their education, the university grew as a place of optimism and advancement. President Truman introduced a massive expansive vision for the university and higher education became available to the masses and not just to the elite. Higher education, once viewed as a privilege, was suddenly accepted as a right [86].

3.1.4 Engineering education in the modern era

After WWII, the importance of engineering education grew as the post-war world looked for economic growth. This was a time of tremendous techno-optimism. For example, Lewis Strauss, head of the US Atomic Energy Commission, predicted that nuclear power would bring a utopia on earth. In a speech given in 1954, he said:

> It is not too much to expect that our children will enjoy in their homes electrical energy too cheap to meter, will know of great periodic regional famines in the world only as matters of history, will travel effortlessly over the seas and under them and through the air with a minimum of danger and at great speeds, and will experience a lifespan far longer than ours as disease yields and man comes to understand what causes him to age [90].

Much of the post-war world was divided into Western capitalist and Eastern communist systems. The technological advancement of Western engineers was, to their surprise, matched by the engineering of the East. When the Soviets launched the satellite Sputnik in 1957, before the Americans had the technological capacity to launch a satellite of their own, Western engineering educators and researchers were called to intensify their research
and development even further. As both Eastern and Western powers competed for technological and ideological superiority, weapons and nuclear research in the engineering labs intensified.

The economic affluence continued into the 1960s, but counter-cultural movements also began to surface, including antiwar and antinuclear protests and the civil rights movement, as the promises of a new and better world did not materialize. This movement only mildly affected engineering education, however, as liberation pedagogy and much of the counter-cultural movements did not reach engineering like other areas [86]. Economic growth was high, and engineers were required for industrialization and the ‘race for space’; engineering schools remained primarily modernist.

Much like in the field of engineering and development, the 1970s saw the optimism of technology questioned further. While it was predominantly believed that sophisticated engineering can solve some of our problems, the idea that a technological fix was possible for all problems was under attack. The Club of Rome’s publication, written to foster better understanding of economic growth, states,

... that technological optimism is the most common and the most dangerous reaction to [their] findings from the world model. Technology can relieve the symptoms of a problem without affecting the underlying causes. Faith in technology as the ultimate solution to all problems can thus divert our attention from the most fundamental problem — the problem of growth in a finite system — and prevent us from taking effective action to solve it. [91]

Anti-technology movements that began in the mid-1960s grew through the 1970s, as many of the ills of society were being blamed on technology. Samuel Florman, in his 1976

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8 Pedagogy for the Oppressed [22] is one example of liberation pedagogy that was popular in the 1960s. Schumacher’s criticism of the ‘idolatry of large’ is another example of a counter-cultural movement that engineering education did not embrace.

9 The Club of Rome is a global think tank.
book *The Existential Pleasures of Engineering*, argues vehemently in defence of engineering and suggests that the doctors, lawyers, and educators were equally to blame and that engineers are following a human drive to create devices and solve problems [82]. The oil crises of the 1970s, however, brought an increased awareness of the role of engineering in society, and engineering education was adjusted to increase the environmental content in their curriculum. New programs in environmental engineering initiated research into new, alternative energy sources. Engineering research, in general, was on the rise again, as was graduate school. While in the 1950s, most engineering professors taught for nine months and then got a job in industry for the summer to supplement their income and to have some experience to bring into the classroom, the 1970s saw professors spending the summer months with graduate students and research. The 1970s also brought an increased focus on communication, management, and engineering economics, in response to industry needs and in hopes of energizing a slowing economy [86].

Global competition shaped engineering education in much of the next few decades. The Japanese economy had rebounded from the destruction of WWII and was starting to dominate many aspects of the global market by the 1980s. In order to compete with Japan and maintain their growth, industries in North America turned to the engineers and the engineering educators to speed up the time between research and marketable products. The relationship between the university and industry continued to get closer during the rise of neoliberalism, seen in the 1980s up until the present day.

For many, the collapse of the Soviet Union in the early 1990s validated the dominance of the capitalist system. For a half-century, the Cold War shaped American science and technology policies, and for the first time economic competition took the place of military competition in the minds of many policy makers and, in turn, engineering educators. As a result, competitiveness in the global economy became a primary concern for engineering education. Internationalization of the engineering program was necessary so that engineers from the West could design and manufacture anywhere in the world [86].
In accordance with neoliberal ideals, national governments have a lesser influence on engineering education in the present decade. As a result, engineering education is run more like a business than a public service, and receives a higher percentage of its funding from industry, students, alumni, and philanthropists. At the same time, a mass increase in the number of students in higher education is forcing the university to become more diverse, more global, and more competitive [92]. Engineering education in North America is forced to evolve as knowledge (as opposed to resources or manufactured goods) is emerging as an important driver of global economic growth. This trend is occurring in a time when Canada and the US cannot compete with other nations for manufacturing labour and increasingly, engineering labour. Engineering curriculum is being called to include modules on global communication, and co-operation with multinational corporations for summer internships and relevant case studies [93].

This aspect of globalization and industrialization, while undeniably changing the face of engineering education, is making many people nervous. The university is being transformed from a place to pursue truth to a place to pursue profit [92]. A recent literature review on science and society points out that closer links between industry and university cause public distrust in scientists [94].

Engineering education has always been tied to the needs of the state or the market. Richard Sclove, in his book *Democracy and Technology*, argues that the public needs to have more of an influence on the usage of technology [95]. A curriculum more centred on human need could do exactly that and is compatible with many growing trends in engineering education, as the next section suggests. Table 3.1 lists some of the important events in the history of Western engineering education, as described in this section.
CHAPTER 3. CHANGING ENGINEERING EDUCATION

Table 3.1: Events in the history of Western engineering education.

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1747</td>
<td>Perhaps the first formal engineering school: military engineering - France</td>
</tr>
<tr>
<td>1800s</td>
<td>The Industrial Revolution in England: an increased need for engineers</td>
</tr>
<tr>
<td>1802</td>
<td>The US Military Academy is established</td>
</tr>
<tr>
<td>1824</td>
<td>Rensselaer Poly. Institute is built to aid development of infrastructure</td>
</tr>
<tr>
<td>1854</td>
<td>King’s College is established as the first engineering school in Canada</td>
</tr>
<tr>
<td>1865</td>
<td>End of American Civil War and start of the ‘Golden Age of Engineering’</td>
</tr>
<tr>
<td>1929</td>
<td>The beginning of Depression; increase in social concerns of engineering</td>
</tr>
<tr>
<td>1939</td>
<td>WWII transforms engineering education; increased engineering research</td>
</tr>
<tr>
<td>1950s</td>
<td>Techno-optimism during the post war economic boom</td>
</tr>
<tr>
<td>1957</td>
<td>The Soviets launch Sputnik and the ‘race for space’ begins</td>
</tr>
<tr>
<td>1960s</td>
<td>The growth of both Cold War and anti-technology movements</td>
</tr>
<tr>
<td>1970s</td>
<td>Oil Crises; curriculum is adjusted for increased environmental focus</td>
</tr>
<tr>
<td>1980s</td>
<td>A growth in global competition and internationalization of education</td>
</tr>
<tr>
<td>1991</td>
<td>Collapse of the Soviet Union; economic replaces military competition</td>
</tr>
<tr>
<td>2000s</td>
<td>Increased interest in social, environmental impact of engineering</td>
</tr>
</tbody>
</table>

3.2 Engineering education today

Up until 250 years ago, technological change in a lifetime was nearly imperceptible. Today, training engineers requires the consideration of very different aspects compared to two decades ago, let alone two centuries ago. The economic and social trends that the engineering profession faces today, shaped largely by the globalization of the markets, includes an increasing number of specializations, the accelerating rate of technological change, information explosion, involvement with more complex organizations, and the rapid expansion of educational institutions. Current engineering graduates are faced with an immensely different world than what their parents faced a generation earlier.

Engineering educators want to ensure that their graduates leave their institutions with the necessary attributes and skills that they will need for careers that will span the next 40 years — a daunting task as the required knowledge is so quickly changing [96]. At

\[10\] A weekend edition of the New York Times contains more information than anyone living in the 1700s would have been exposed to in a lifetime.
the same time, in North America, engineering enrollment is declining [18], fewer students trained in engineering are choosing to work in engineering positions [97], and female and minority interest in engineering in North America is decreasing\textsuperscript{11} [27]. Engineering students appear to be increasingly unclear about their role in their community, outside of simply ensuring their own employment [98].

At the same time, the growing power and efficiency of technology, while producing so much wealth and change, are not unrelated to many growing problems. Engineering educator Bill Vanderburg attributes the spiralling health costs, global unemployment, the growing gap between the rich and poor, and the large national deficits to engineering advancements [9]. A future with a significant increase in urban populations, severe environmental degradation, and an aging population in high income countries suggests that these problems will not be easy to mitigate.

These changing times for engineering education often lead to necessary discussions on how engineering can be more relevant to the current needs. The National Academy of Engineering (NAE) in America has been working on a major project known as The Engineer of 2020 [99, 100]. Table 3.2 lists some of the attributes that they have identified as critical for the engineer of the future. The Professional Engineers of Ontario (PEO) have completed a similar project and have concluded that engineers must add a human element to the high-tech approach we see today [101].

<table>
<thead>
<tr>
<th>Analytical skills</th>
<th>Practical ingenuity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creativity</td>
<td>Communication and teamwork skills</td>
</tr>
<tr>
<td>Business and management skills</td>
<td>High ethical standards</td>
</tr>
<tr>
<td>Professionalism</td>
<td>Lifelong learners</td>
</tr>
<tr>
<td>Leadership</td>
<td>Bridging public policy and technology</td>
</tr>
<tr>
<td>Dynamism/agility/resilience/flexibility</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.2: Attributes of the NAE’s Engineer of 2020 [99]

\textsuperscript{11} In fact, female enrollment peaked in about 2000 and has been slowly declining since.
These goals for the future bring up an additional question: should the engineering profession not already be people-focused? That is, after all, what much of the documentation of the profession states. The Code of Ethics that governs the Professional Engineers of Ontario, for example, clearly states that engineers have a ‘duty to society, which is to regard the duty to public welfare as paramount, above their duties to clients or employers’ [102]. Is not all engineering humanitarian? Many authors, both engineers and non-engineers, argue that much of the effort of engineering focuses on the profit-making dynamic of capitalism and does not immediately aid the majority of society [103, 104, 105]. This section will take a deeper look at the typical engineering pedagogy. With a critique of this pedagogy and practice, a basis for a humanitarian engineering program can be made.

While there is still much discussion about how engineering education must meet the demands of industry and the market, there is a need to widen this narrow focus. Historian David Noble warns that market-driven technical developments are often made because of patriotism or competitiveness, which typically result in control and domination [85]. Engineering educator Ursula Franklin suggests that engineering education must look beyond market growth and must promote justice, restore reciprocity, favour people over machines, promote conservation over waste, and favour reversibility over irreversibility [19]. In an analysis of the work of the development agency Engineers without Borders (EWB), Claes Helgesson states that young engineers are getting frustrated at being tied up with solving problems for wealthy people as they are becoming increasingly aware of global poverty [73]. The future of engineering lies in the debate about the extent to which social science and cultural issues should permeate the whole of engineering education.

12See [26, 106], for example.
3.2.1 Technology and society: the reflexive engineer

Similar to how the field of development demanded a deeper understanding of the social and political influences of technology, there is an increasing number of links between technology and society to be discussed in the engineering curriculum. Technology is a reflection of, and at the same time reflects the economic, social, cultural, and political context.\textsuperscript{13} Much evidence suggests that engineering and engineered systems are shifting to take into account concerns beyond the narrow technical domain; engineers are beginning to take a much more integrated view of socio-technical systems \[107\]. But engineering curriculum does not typically reflect this change in thinking \[9\]. Engineering has been struggling for some time with the problems of an extremely packed undergraduate curriculum, constrained by accreditation requirements, with virtually no room for additional material, including non-technical material \[108\]. The possibility of a fifth year\textsuperscript{14} or a professional program has been discussed for many years \[109\], yet practically all that has happened over the past years is a more disconnected and fragmented curriculum \[1\].

Historian John Burke suggests that from the late 19th century on, engineering journals, education reviews, and commencement addresses have been requesting a broad education background \[109\]. In some ways, not much has changed in over 100 years. Today, while professional accreditation boards ask for educators to help students understand the impact of technology,\textsuperscript{15} students are rarely given more than one or two courses on topics related to broader technological impact. In addition, these broadening courses are seen by the student to be of marginal importance relative to the technical coursework. Worse, studies

\textsuperscript{13}Technology and society are deeply intertwined, and thus engineers should avoid technical determinism and also social determinism. The current thinking is that socio-technical systems are the product of the interaction between the social shaping of technology and the technological shaping of society \[42\].

\textsuperscript{14}In 1906, Herbert Sadler, University of Michigan, warmly endorsed a 6 year combined literacy and engineering program \[109\].

\textsuperscript{15}The 2006 Accreditation and Criteria Procedures of the Canadian Council of Professional Engineers (Section 2.2.7) states that “Each program must ensure that students are made aware of the role and responsibility of the professional engineer in society. Appropriate exposure to ethics, equity, public and worker safety and health considerations and concepts of sustainable development and environmental stewardship must be an integral component of the engineering curriculum” \[110\].
consistently indicate that engineering students know little about related topics such as sustainable development [111] and technology policy [112]. In his classic analysis of higher education, Ernest Boyer suggests that the university has failed to address the current social/economic/environmental problems because of the strong focus on the paradigm of pure science (scholarship of discovery). Boyer proposes that the development of a scholarship of engagement, which tries to answer the ‘So What’ questions, can help reshape the university to address pressing social, political, economic, and moral ills [1].

There are many engineering educators advocating for a broader curriculum. Jahan and Mehta argue that a broader, more holistic approach must go beyond a couple of courses and must be reinforced in all traditional engineering courses [113]. Johnston says that engineering education “must deal with both technical and broader social, political, economic, and ecological challenges ... or engineering education will become a place of uncritical training for the masses” [80]. There are some key players, including representatives of the World Bank, however, that think engineers should not be involved with policy, and should focus only on the implementation of technology [114]. This thinking is founded in the opinion that everyone should focus on what they are good at and that progress can be made once all of the roles are carried out properly. This reductionist rationale was strongest in the 1950s [1], and is being challenged with increasing frequency.

Education has to be meaningful. A study completed by the Higher Education Research Institute (HERI) at the University of California, Los Angeles, suggests that today’s university students seem to be wanting a more complete education — one that is as much about how to live as about how the world works [115]. One purpose of the university must be to experience the awe and amazement of the world: Einstein said that the ‘fairest thing we can explore is the mysterious’ [62]. But, because of its applied nature, the education of engineering is different than science or math education. In light of the neoliberalist society
in which we live, it is easy to see that engineering education will be used for national competitiveness and profit. Ursula Franklin argues that engineering education must have a community component: ‘the purpose of a university is not only to be a place where knowledge and understanding find a home, but also to provide a bridge for interaction with the larger community’ [19]. Similarly, Bowden argues that serving the community is one of the three main functions of the modern university, along with teaching and research [117].

There is an obvious need for a market and jobs, but the challenge for the engineer and the engineering educator is to seek an appropriate balance with the local community in mind, knowing full well that the perfect balance will never be achieved completely. Corporate Social Responsibility (CSR) is one initiative to bring about more ethical business practices that has received much attention. There are many criticisms about CSR as it works within the current economic system and does very little to challenge the logic of profit motives, and in fact are often used to increase marketability [105]. These exercises in social enhancement, whatever the motive, can accomplish much, but must be monitored with skepticism.

Willem Vanderburg suggests that engineering can become more relevant if it takes a more preventative approach. Too often, engineered systems are deemed appropriate if they generate a profit, regardless of the negative social or environmental problems. Environmental engineers are often called after the fact. Vanderburg argues that changes to engineering education, corporate practice, and organizational culture are necessary for a preventative approach. He suggests that engineering students will find a preventative oriented curriculum more relevant and interesting, boosting motivation and reducing dropout rates [9]. Critical thinking, beyond simple skills development, will cause people to reflect on motives.

Several authors [98, 107] have suggested that an engineer with an increased awareness,  

\[16\] Canada’s Natural Sciences and Engineering Research Council (NSERC) states the following in one of their prospectuses, for example: ‘To enhance Canada’s economic performance, we have to become more productive, which, in a knowledge-based global economy, means becoming more creative and innovative’ [116].
or reflexivity, should be the model engineer for the next decade. Reflexivity refers to the human capacity to use the available information to make important life decisions, but it also refers to the ability to consider the consequences of action that could impact carefully made plans, knowing full well that one can never completely know all consequences [98]. In the case of the engineer, this is an integrated understanding of socio-technical systems [107]. Robbins calls for ‘a new integrative principle, not a new set of tools, so the concept cannot simply be regarded as an add-on to existing engineering skills and education programs’ [42]. Adding material is not just ineffective, but it is also impractical because of the very full curriculum, as suggested earlier.

Unfortunately, the current focus of the engineering curriculum is on the traditional sciences, which often fails to allow students to experience the link between the practice of engineering and the ideals of environmental and social sustainability. Instead of linking the various fields of study together, discipline-specific knowledge is often taught in isolation. Even within a single discipline, subjects are taught as isolated units [1]. Vanderburg also argues that the socio-technical systems must be introduced in a holistic way:

As an engineer, I learned very little about technology as a whole. ... In terms of understanding how technology fits into, evolves and interacts with society, my social science and humanities courses did not teach me very much. ... Unless I can connect the micro-level nitty-gritty aspects of my daily-life practice of engineering to the larger, broader patterns within which we live and evolve both as citizens and professionals, my ability to effectively exercise my social responsibility is greatly impaired. ... I never learned anything about the limits of engineering methods and approaches in school. [119]

This opinion is not unique or new. In his famous 1959 essay, *Two Cultures*, C.P. Snow said the gap of understanding between technical people and non-technical people is the

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17 This includes engineering history. Kevin Hurst argues that engineers must know history [118].
most important hindrance to solving the world’s problems. He argued that we need to create thinkers who can reason about both social and technical problems, but that we are failing at doing this [120]. Engineering educator, Harold Sjursen argues that engineering must go beyond the recommendations set by the NAE. The goals of a more holistic curriculum can only be met, in his opinion, ‘when both the liberal arts and engineering are reconsidered as specifically human disciplines.’ He calls for all universities to integrate their liberal arts and engineering programs and praises the growing trend towards academic centres for liberal arts in engineering education [121].

Florman argues that humanities courses will not necessarily improve the engineer. The humanities do not directly foster political democracy or settle international disputes, but he does say that the:

\[
\text{study of liberal arts will rob [the engineer] of his innocence, stain his character, make him less “moral” — or at least, less naive. And this is exactly what the engineer needs. ... With the religion of Progress lying in ruins about us, we engineers will have to relinquish, once and for all, the dream of priesthood, and seek to define our lives in other terms.} \quad [82]
\]

David Orr, in his essay *What Is Education For?*, echoes Florman’s opinion. He says it is not education that will save us, but education of a certain kind. In his essay, he calls for a broader education that enforces the idea that ‘knowledge carries with it the responsibility to see that it is well used in the world’ [122].

### 3.2.2 Engineering ethics

An argument for change can be made by looking at the underlying ethical foundation for the engineering profession. In engineering, the codes of conduct put forward by different engineering societies have been developed to help regulate the behaviour of practising engineers. While professional engineering documentation is filled with statements regarding
the benefits of the public and the enhancement of human welfare, and the academic discipline of ethics explicitly suggests that engineering ethics govern the arranging, defending, and recommending right and wrong behaviour, there are important details that are not stated clearly. The ambiguity in the codes of conduct (such as the definition of the word ‘public,’ for example) often renders them ineffective or easily ignored.

In a survey of many of the major engineering codes of conduct,\textsuperscript{18} Catalano suggests that there is much discussion about the importance of holding paramount the public safety, but some very important details are skipped:

- There is no mention of the intimate connection between engineering, and war industries and terrorism.
- There is no mention of the challenge of world poverty.
- With the exception of the ASCE, the challenge of environmental sustainability is ignored\textsuperscript{19} [123].

Catalano argues that the world in which engineers work has dramatically changed and there is a need to examine our sense of ethical responsibility in light of a new paradigm. Our ethical codes of conduct need to be more indicative of the science of the the 21st century rather than the 18th and 19th century, when much of the moral philosophy around science and engineering was laid out [123]. Our understanding of technology and society has dramatically changed since even the mid-20th century and the fundamental ethics need to reflect that. Vesilind suggests a similar notion in his book \textit{The Right Thing to Do}. He says that the current code of ethics is fine as only a first, rough tool for making decisions

\textsuperscript{18}Catalano looked at the Code of Conduct from the American National Society of Professional Engineers (NSPE), the American Society of Mechanical Engineers (ASME), the American Society of Civil Engineers (ASCE), the Institute of Industrial Engineers (IIE), the American Accreditation Board for Engineering and Technology (ABET), and the American Institute of Chemical Engineers (AIChE) [123]

\textsuperscript{19}Engineers should seek opportunities to be of constructive service in civic affairs and work for the advancement of the safety, health and well-being of their communities, and the protection of the environment through the practice of sustainable development [124].
in engineering [125]. Karl Stephan says that the ‘engineering ethics gap’ can be filled with the Golden Rule\(^20\) in his paper, *The Only Ethics Rule You’ll Ever Need* [126].

Sjursen points out that meaningful change requires more than just changing the ethical code of conduct. Issues around ‘the good life’ and the basis of duty have divided philosophers for centuries and much of these discussions are embedded in religious, cultural, political, economic, and scientific thought. For the bulk of the history of engineering, engineering practice has been seen as a neutral endeavour; but the more engineering becomes the major mode of human action to resolve human problems, the less it can get away with this value reference [127]. He concludes that in addition to clearer codes of conduct, engineering educators need

... to take the lead, to begin the conversation and to expand the legitimate discourse of engineering in order to produce more enlightened understanding about the way that technology forms the world. [127]

Engineering educator Caroline Baillie makes a similar point about interpreting engineering ethics. She says that sometimes things are legally right, but morally wrong. Being ignorant of the impact of our work on the lives of individuals and communities is also unethical and as engineers, we must constantly be asking, *Who Benefits from Our Engineering?* [105]. In her book *Whose Brave New World*, Heather Menzies warns against a culture of compliance, where this question is not asked. She says that through our educational institutions, people are trained to comply to an environment of computer monitoring and performance measurements and are kept from seeing the big picture [128]. Jeff Schmidt in his book *Disciplined Minds* describes a similar scenario. The education of professionals, including engineers, he says, is intended to encourage a specific way of thinking: “The ideology of the status quo is built into the curriculum. The professional’s objectivity, then, boils down to not challenging this built-in ideology” [129].

\(^20\)Do to your neighbour as you would have him do to you.
Other voices suggest that workers willingly participate with this current work model and that this participation is necessary for efficiency and competitiveness. Regardless of where one falls on the argument of education and a culture of compliance, many engineering educators are increasingly demanding that their students question the common sense view of the world around us to ensure that we are not contributing to an increasingly unequal world. In her Massey Lectures, Ursula Franklin stresses that it is up to the engineers to ensure that we are aware of the way in which our engineering practices contribute to social, economic, and political issues in order to make responsible choices [19].

3.2.3 Engineering design and creativity

Engineering achievements must be assessed by considering their social, economic, and environmental impact in both space and time; a new technology will affect other cultures as well as future generations. The reflexive engineer looks beyond the technical, analytical, and professional skills as the boundaries of engineering are expanding. Today, the most pressing technical problems society faces go beyond an application of math, physics and chemistry. Engineers today must integrate their technical and non-technical abilities and consider social constraints as a major part of the design process.

While many consider engineering and design to be synonymous, others break engineering into analysis and design, with design being the creative side of engineering. While the organization and teaching of engineering follows the orderly pattern of division and sub-division of knowledge, design is the art of bringing the sub-specialities together. This requires a judgement and compromise between the various specialities.

Thomas Hanson, in his book *Engineering Creativity*, says that design is the inverse of analysis [87]. Analysis requires the student to analyse a device that has already been created, while design creates a device with specific constraints: there is always more than one correct answer. Hanson states that it is problematic that the bulk of engineering is taught from an analytical point of view and that so many view engineering as objective. The
world is not neat and orderly, despite what many engineering educators seem to suggest. Much of engineering, in his view, ignores the creative process, while in fact the engineer has more in common with the artist than the scientist [87]. (The difference between the engineer and the artist is that the engineer is constrained by the realities of the physical world.)

Creativity or creative thinking, related to the inner-workings of the mind, is not well understood. Engineering clearly requires thinking from both sides of the brain: logic and analytical thinking from one side and sensitivity and creativity from the other. Exercising both sides of the brain is shown to produce a sense of psychological wholeness [130]. In light of this, Hanson argues that engineering is too analytically focused and too specialized. Without a focus on the creative side of engineering, students will more readily resort to not thinking and will have an inherent resistance to change [87]; creative designers need a broader education.

Thus creativity also links design to ethics. The more creative the engineer, the greater the moral responsibility to use her or his talent constructively according to Hanson. More creative thinking leads to more confidence, which is required for ethical living. While many people will avoid thinking for themselves, a confident engineer will be more willing to fight for what is ethical, according to Hanson. He uses the example of ‘whistle blowing.’ An engineer who focuses purely on the analytical is going to be more likely to show company loyalty even when the company is doing questionable things (safety, pollution, exploitation, fraud), as much of the broader picture will not be obvious [87].

The best design, according to the Canadian Engineering Accreditation Board (CEAB), requires the best compromise between conflicting requirements, which may be governed by standards or legislation, or may relate to economic, health, safety, environmental, social, and other interdisciplinary factors [110]. While this sounds very promising, often decisions are made largely based on national power and economic growth. Cruickshank and Fenner suggest that there is no technological barrier to working as engineers in a sustainable way,
but that we often fail to pose the design problem properly. While engineers are often seen as ‘problem solvers,’ there is a need for a broader, multidisciplinary approach\textsuperscript{21} to ‘problem definitions’ [132]. George Catalano calls for a new approach to engineering design, something he calls \textit{A Revolution of the Heart}. He offers the following questions to be asked of any designed product and recommends that these questions be incorporated into the design cycle [133]:

- Does it empower? Who does it help?
- Has suffering in the world been reduced?
- Have the social injustices that pervade our global village been even slightly ameliorated?
- Has the notion of a community of interests been expanded?
- Is the world a kinder, gentler place (borrowing from the Greek poet Aeschylus)?
- Does it address root (or current) problems?

A ‘Revolution of the Heart’ would require a tremendous shift in pedagogical thinking. Chambers suggests that the research and education community’s focus on the needs of the rich, elite, and powerful is deeply entrenched.

Prolonged professional conditioning has built biases of perception deep into many of those concerned with development. .... Many interlocking influences shape ambitions, mould ways of seeing things and sway choices of where in the world one is to work. These include textbooks, curricula, examination

\textsuperscript{21}In their seminal book, \textit{The new production of knowledge}, Michael Gibbons and his colleagues argue that a new form of knowledge production is emerging. This form of knowledge production is context-driven, problem-focused and multidisciplinary, and has been labelled, ‘mode 2’ knowledge production. It is replacing traditional research, or ‘mode 1’ knowledge production of investigator-initiated and discipline-based research [131].
questions, professional journals, academic awards, national and international distinctions, professional values and ideas of sophistication, the media, the priority accorded to armaments and security, the desire of elites for international mobility. [55]

Kammen and Dove, in their paper called The Virtues of Mundane Science, also discuss how to bring ‘heart-thinking’ into the design process. They claim that the primary obstacle to meaningful design is a ‘lack of integrated approaches to complex systems and problems.’ They warn about the appeal of high profile or cutting-edge research and encourage designers to focus on the everyday issues that would make much more impact in people’s lives. The authors argue that focusing on the mundane would not only have a much greater impact, but also requires significant research and deep understanding of science. They use the cookstove as an example; a more energy-efficient stove could decrease the amount of charcoal or wood needed and could greatly improve air quality in the home. Optimizing the stove design, according to Kammen and Dove, would require a deep understanding of many engineering (and non-engineering) subjects and would have a tremendous influence [134]. Engineering design education could be improved if the bias against the mundane is removed from all aspects of the education process — from the research funding to the in-class curriculum delivery.

3.2.4 Engineering and development curriculum

The previous subsections have described an engineering education field in flux. Many researchers and educators are calling for new ways to understand the social role of engineering, engineering ethics, and engineering design. Historically engineers have been employed as “hired guns, doing the bidding of both political rulers and wealthy corporations,” but as Vesilind observes, there is a new kind of engineering emerging, one “rooted in the greater ideas and aspirations of engineering as a service to all humanity” [135]. This
will in turn lead to a change in engineering curriculum and accreditation standards. Robbins also predicts that we are at the beginning of an emerging field in engineering [42].

One piece of evidence to suggest that a new trend is materializing is in the marketing of the engineering field. Engineering schools are promoting their discipline as one that is for the global good, often using stories of engineering and international development as an example. In an advertisement for the University of Idaho, for example, there is a story about a water engineering project in Peru, which includes the line, “If you want to save more lives, become an environmental engineer rather than an M.D.” [136].

The popularity of campus engineering and development clubs, such as Engineers without Borders (EWB), is another indication of the changing attitudes of engineers. There are active EWB, Engineers for a Sustainable World, and Engineers for World Health clubs at universities all across North America. EWB-Canada for example has nearly 6000 student members and 27 student chapters [137]. The student members of EWB are active with education, outreach, and awareness events, as well as working with their university’s faculty in curriculum enhancement. The University of Calgary, Université Laval, McMaster University, University of Western Ontario, and the University of New Brunswick are listed as institutions that are leaders in working with EWB for curriculum enhancement [137]. The introduction of the curriculum enhancement material from EWB with the first year engineering design and communication course at the University of Calgary is considered a tremendous success [138]. The Queen’s Project on International Development (QPID) is a similar student group at Queen’s University with its roots in the Applied Science Faculty.

Many universities are sensing this trend and moving accordingly. There are courses, seminars, and programs being introduced around the idea of ‘development,’ with many different understandings of development, of course. Cruickshank and Fenner argue that the evolving role of the engineer must include sustainable development [132]. In this case, the term sustainable development not only means a balance of environmental, social, and
economic considerations,\textsuperscript{22} but also is used to refer to participatory development in a low income community.\textsuperscript{23} The terms ‘human development,’ ‘community development’ and ‘international development’ are also being used in the emerging curriculum. Because of the many terms and because so much has been written about development, it is hard to make the necessary connections with engineering at the day-to-day level of practical implementation. This is a challenge of curriculum design.

While many schools have been adding seminars and adjusting courses in response to the trend of moving towards more engineering and development, only a few have incorporated more comprehensive programs.

- The \textbf{Colorado School of Mines} began its Humanitarian Engineering program in 2003 to address the needs of the poor in other countries. CSM offers two different Humanitarian Engineering minors and an area of special interest in humanitarian studies to its engineering students. The goal of this program is to balance technical abilities, economic feasibility, ethical maturity and cultural sensitivity. An international placement is a key component of this program [79, 139].

- The engineering faculty at the \textbf{University of Colorado at Boulder} started a similar program in 2004 called Engineering for Developing Communities. This program is headed by Dr. Bernard Amadei, the founder of Engineers Without Borders-USA. This program started as a Master’s degree option; an undergraduate program was later added in 2006. The goal of this program is to ‘develop globally responsible engineering students and professionals who can offer sustainable and appropriate solutions to the endemic problems faced by developing communities worldwide’ [140]. The University of Colorado also has a Center for Appropriate Technology which works closely with the program [141].

\textsuperscript{22}Sometimes referred to as the triple bottom-line.
\textsuperscript{23}Cruickshank and Fenner’s obvious and intentional ambiguity points out the necessity of clearly defining terms used around ‘development.’
• The ETHOS (Engineers in Technical, Humanitarian Opportunities of Service-learning) group at the University of Dayton was developed in 2001 to study the linkage of engineering with culture, environment, politics, society and values. Students get involved through appropriate technology courses, a student club, and international internships [142, 143].

• There is a Peace Corps Master’s program available through Michigan Tech’s Civil and Environmental Engineering Department. In this program, students work in an engineering field project as a requirement for their degree. Typical projects are related to water supply, sanitation, watersheds, and erosion control and have been conducted all over the world. This Master’s program is intended to prepare students for a Peace Corps assignment [144].

• A program called EPICS (Engineering Projects in Community Service) began in 1995 at Purdue University and is now at 17 different American universities. The purpose of this program is to allow undergraduate students to gain credits toward their degree by using their engineering skills in local community service. The student projects are split in to four topic areas: human services, access and abilities, education and outreach, and the environment [145]. Aspects of this program include work with local community, multidisciplinary work, vertically-integrated (includes students from all years) and long-term projects.

• Professor Amy Smith of the Massachusetts Institute of Technology has founded the D-Lab (development lab), the IDEAS Competition [146], and the International Development Design Summit (IDDS) [147], all of which were developed to assist students in creating appropriate technology for low-income countries.

This list is not meant to be exhaustive; there are many more universities becoming involved with engineering and development, including Michigan [148], Baylor [149], Howard
[150], and Rowan University [113] in the USA. Bielefeldt et al. give a more extensive (but far from complete) list of related programs in their survey paper [151]. Bielefeldt et al. mention a few related programs in Europe and the UK as well, including the University of Surrey and the Centre for Sustainable Development at the University of Cambridge. Aalborg University in Denmark and the University of New South Wales (UNSW) [152] are two other international universities that boast a growing focus on engineering and development.

3.2.5 Service learning

Service learning, a new pedagogical approach especially popular in the USA, is often associated with engineering for development. Service learning is defined as a form of experiential education in which students apply their knowledge and skills from the classroom in projects designed for human or community need. The reflective process is an important part of service learning [153]. Educators claim great success with service learning in engineering because of the practical design experience, opportunity to develop communication skills and as means to see technology in a broader perspective [154]. Service learning is beneficial in teaching civic responsibility and for strengthening community, while enabling engineering education to address issues of the environment and poverty [155].

Service learning most often refers to service work within the local community, but international placements are growing in popularity, especially as service learning activities are increasingly promoted through the EWB-USA student chapters [113]. Borg and Zitomer praise international service learning because of its role in achieving ‘broader education goals’ [155]. Amadei suggests that the developing world will be ‘the classroom of the 21st century’ [140]. While service work may only have a small impact on the community, experiencing poverty can really help shape the engineer. Often the benefits to the student are difficult to define or measure, but the long term, gradual learning is difficult to deny.

There are some concerns about the growing pedagogy of service learning. Volunteer
work for an academic credit is something of an oxymoron. Students who are expected to provide community service and reflection will sometimes resort to seeing the tasks as part of a check-list. Another concern is expressed by Riley, who argues that seeing the developing world as ‘the classroom of the 21st century’ is simply a new twist on neoliberalism [103]. International service learning has also been compared to colonialism, where a positive learning experience is one more thing to take out of the developing world.

Marc Epprecht who has written about student international development placements, says that any placement comes at great cost and high risk. It is widely believed, according to Epprecht, that “the work-study abroad experience is so intrinsically valuable that neither the ethics nor the pedagogy requires dedicated reflection and analysis” [156]. He fears that “work-study programs contribute to the very kinds of underdevelopment and colonial-style North-South relations that they are intended to critically address.” In the end, he gives 13 topics that must be discussed and understood before departure [156]. Hammer gives a similarly useful list as he identifies 10 reasons for failed international service projects [157].

While the value of the academic exercise is difficult to deny, the actual contribution to the community being ‘helped’ is another question. Technical solutions are useful for surface problems but sometimes miss the root of the problem. Marullo and Edwards, in their paper *From Charity to Justice*, suggest that getting at the root of the problem is often much more difficult and interdisciplinary in nature; often the problems are more economic or political [158]. Boyer calls for a scholarship of engagement with holistic, integrated, and collaborative thinking to get to root causes [1]. Marullo and Edwards suggest that service learning is not enough: “How can we be experiencing greater than ever levels of community service and at the same time be suffering from a decline of civic life?” They argue that charity reproduces the status quo while social justice can be an active promoter of a more just society. They call for a transformation of the university by moving from a pedagogy of charity to one of justice, which will in turn transform the community [158].
Table 3.3 highlights some other important tensions within engineering education that have been highlighted in this chapter.

<table>
<thead>
<tr>
<th>Higher education for the masses or for a few?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance between a technical and non-technical curriculum.</td>
</tr>
<tr>
<td>Balance between research and teaching in the university.</td>
</tr>
<tr>
<td>How much industrial support is appropriate?</td>
</tr>
<tr>
<td>Balance between objective/quantitative and subjective/qualitative.</td>
</tr>
<tr>
<td>Balance between analytical and fostering creativity.</td>
</tr>
</tbody>
</table>

Table 3.3: Issues of tension in engineering education.

In closing this chapter on engineering education, it is important to note that not all engineering is driven by profit. There has always been a social strand to engineering practice — the term ‘civil engineering’ can historically be translated as ‘engineering for the people.’ Vesilind, in his article *Peace Engineering*, suggests that more career opportunities are becoming available to engineers outside of military and industrial applications [135]. Engineering education should reflect these other career options. Vesilind says that an increasing number of engineers are going to be Peace Engineers, working with NGOs, health organizations, development agencies, the Peace Corps, and Engineers without Borders, for example [135].

Also, within industry, there is a growing concern for the social impact of product design. The Corporate Social Responsibility (CSR) movement, as hypocritical and insincere as it sometimes seems, is one indication of this phenomenon. Another indication is the plans of ISO 26000, by the International Organization for Standardization, to be published in 2010. ISO 26000 will be a guidance standard on social responsibility for all types of organizations (corporate, governmental, non-governmental) [159]. ISO 26000 will be voluntary, but there are several countries already planning on making it a regulation, including Brazil and Sweden. In light of this growing trend, engaged and broadly educated engineering students have the potential to make an important contribution. Neither anti-technology
thinking or technology-neutral thinking are useful; it is critical for the engineer to understand how technology, engineering, the market, and the state have been intertwined since the beginning of engineering education.
Chapter 4

Research approach

Those who speak most of progress measure it by quantity and not by quality. – George Santayana

Have you ever tested the civil courage of your countrymen? The silently accepted motto is leave it alone and say nothing about it. – Albert Einstein

Sitting, asking, and listening are as much an attitude as a method. Sitting implies lack of hurry, patience, and humility; asking implies that the outsider is the student; and listening implies respect and learning. – Robert Chambers

Qualitative research interviews were selected as the desired means to answer the research questions posed in Chapter 1. Research interviews were chosen because of the natural compatibility between the social role of engineering and conversation as a way of constructing, transmitting, and understanding knowledge. In addition, as discussed in the previous chapter, engineering requires activity from both sides of the brain, so using qualitative research can complement a discipline that focuses primarily on quantitative methods.
Besides the fact that the human reality may be understood as persons in conversation and that engineering requires a non-technical approach in addition to a technical approach, qualitative research interviews are appropriate for several other reasons as well. For example, qualitative research:

- Allows for the existence of multiple realities.
- Allows social phenomena to be understood from a variety of perspectives.
- Provides a deeper understanding of complex social and technical phenomena.

The reasons above contributed to the eventual decision that qualitative research interviews were the obvious approach to this research project.

Before describing the research methods used for this study, the meanings of the words *methodology* and *methods*, for the purpose of this project, must be defined. These terms are sometimes seen as synonymous, but will take on distinct meanings for this project. First of all, a methodology is the theory or underlying principles that dictate how the research should proceed. A research method is the technique used for actually gathering the evidence. In other words, the methodology is like the credo that defines who will be interviewed, how the data will be collected, and how the data will be analysed, while the methods describe the details of exactly how each of these steps is carried out.

### 4.1 Methodology

#### 4.1.1 Qualitative research methods

In their *Handbook of Qualitative Research*, Denzin and Lincoln suggest that everyone approaches the world with a framework or a set of ideas that in turn specify a set of queries
CHAPTER 4. RESEARCH APPROACH

about given phenomena, which leads to a specific way of examination [160]. The qualitative researcher must discuss his or her perspective in terms of being, knowing, and finding out — he or she must describe his or her own world-view or methodology. The world-view of an engineering researcher, while still important in order to interpret results, is seldom specified, and thus is often assumed or taken for granted.

Sociologist Adele Clarke points out that we are in the midst of a renaissance of qualitative approaches to research. In the past, even in social sciences, non-tenured researchers were limited to quantitative research. After achieving tenure, a professor could then dabble in qualitative approaches. Qualitative methods are now reaching many fields including sociology, economics, medicine, and even engineering [161]. It is difficult to claim objectivity in many research fields, and a new template for academic study — one which stands in contrast to the rational, neutral, modernist scientific template — allows for a more honest approach. This is perhaps, the only way to address collaborative, multidisciplinary studies.

In any qualitative publication, a researcher will typically specify her or his overriding methodology — usually a methodology that has been accepted and adopted by the academic community. This accepted methodology consists of rules and procedures for the analysis of the principles of inquiry, such as rules for data collection and analysis. In many cases, the accepted methodology is given slight adjustments to match the researcher’s personal values, biases, and interpretations, although these adjustments are not usually reported. Much of the methodology used in this study is described by a methodology known as phenomenography.

1In the field of metaphysics, one’s specific framework can be analysed through the study of being, or ontology; the set of questions is analysed through the study of knowing, or epistemology; while the method of examination can be described through the science of doing and finding out, or methodology. The metaphysical terminology is avoided in this thesis because of the conflicting use of the word, 'Methodology.'

2While it can be argued that the engineering researcher’s methodology is non-critical in interpreting physical phenomenon, her or his world-view is essential to understand why the physical phenomenon is important.
4.1.2 Phenomenography

Phenomenography is a qualitative methodology that focuses on the variety of ways in which individuals describe or perceive a specific phenomenon, such as the concept of surface tension or social justice. The roots of phenomenography can be traced to the 1970s and the research headed by Ference Marton at Göteborg University, Sweden [162]. Marton’s research group was initially interested in the variation of how students learn, and through their research, discovered that students typically gave dramatically different interpretations of certain texts [163]. The many different interpretations led the researchers to categorize the various degrees of understanding, and eventually describe a hierarchy of understanding. This hierarchy included an increasing amount of structure in each category of description, creating an inclusive hierarchy, such that if someone’s understanding matches a specific category, he or she will be able to relate to all previous modes of understanding as well. Phenomenography emerged from these investigations into learning variations, and the term was first used by Marton in 1981 [163].

The phenomenographic tradition, thus, aims to describe the critical aspects in the variation of ways of experiencing a specific concept. In this methodology, the research data, such as transcribed interviews, is pooled together to form one source. This pool of data is then organized into various categories of description, which in turn are organized into some sort of structure, which is often hierarchical. The structured data, called the categories of description, or the outcome space, represents the possible ways a concept can be understood or experienced. The individual conceptions are not important in phenomenography, as the goal is to reach a description of variation of the collective [164], and hence the pooling of the data. Figure 4.1 gives a graphical depiction of phenomenography.

In phenomenography, there is a fundamental distinction between how a phenomenon is experienced by an individual (a first-order perspective\(^4\)) and how a phenomenon is

\(^3\)In this thesis, the words phenomenon and concept are used interchangeably.
\(^4\)Most traditional scientists use a first-order approach.
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Figure 4.1: A graphical representation of the phenomenographic methodology.

experienced through conversations with others (a second-order perspective). The phenomenographic researcher seeks to understand the relationship between the interviewee and the phenomenon inductively through the conversations [165].

Phenomenography is a useful qualitative research methodology because it is concerned with the understanding of concepts and in variation. Through being exposed to different ways of looking at something, one can better understand it. Through being able to determine an outcome space, one can get a sense of deeper conceptual understanding. In educational situations, a deep approach to learning occurs when the way one experiences a phenomenon changes, and thus effective teaching occurs in situations where such change is fostered. In qualitative research, an analytical description of the variation provides access to the deep understanding necessary to make conclusions and recommendations. Phenomenography has been successfully and widely used in many countries and in a wide variety of research applications (see [112, 162, 166, 167], for example), including Civil Engineering Education [168].
The relationship between a given learner and the phenomenon will obviously manifest itself in different ways, depending on the exact situation — this sort of variation is inherent. Just as every human is an individual, every human experience is unique. Ingerman states that our experiences of anything are always embedded in a context [162]. However, numerous phenomenographic studies have suggested that overall, collective conceptual experiences can be described in a limited number of qualitatively distinct categories [164]. Marton and Booth suggest that if the number of ways of experiencing a phenomenon were infinite, then we would live in different worlds, being unable to communicate with each other. Since this is not the case, the number of ways of experiencing a phenomenon must be finite [164].

This leads us to an essential question: If there is a finite number of ways of experiencing something, is there a correct way? Phenomenographic theory tells us that because everyone, including the phenomenographic researcher, has a distinct experience with the specific concept, it is impossible to know the ‘correct answer’. No explanation can be interpreted as being superior to another or closer to some general truth. The various levels of understanding in the outcome space say nothing of the phenomenon’s true nature — just how they are experienced by humans. But we, as humans, are always judging interpretations — often determining one thing as better than another. We are required to understand what a situation is about in relation to a particular goal, or how to deal with a certain situation, and this will therefore require a certain amount of judgement.

Phenomenography is founded on the outcome of nearly 30 years of empirical research and can be a useful methodology for this specific study as well. The research questions can be rephrased so that they inquire about the understanding of several phenomena or concepts, including

- The social role of engineering
- Humanitarian engineering as an academic field of study
• A humanitarian engineering placement

• Engineering as means to practice social justice

In phenomenographic studies, learning is something experienced by both the interviewer and the interviewee, as both are exposed to new ways of experiencing the topical phenomena. The research interviews in this study have been designed so that even though the interviewer is directing the flow of the conversation, learning is two-directional. In addition, it is desired in this study to interview a broad variety of people, including engineers, non-engineers, academics interested in development studies, and members of community groups, and thus, the phenomenographic tradition is appropriate as it requires a great variation in attitudes and personalities from the interviewees.

Like any methodology, the phenomenographic tradition will influence how interviewees are selected and how data will be collected and analysed. These details will be described later in this chapter.

4.2 Researcher bias

In his PhD thesis, Ingerman suggests that the object of research is “embedded in a context,” and that this context gives a specific meaning to the research [162]. Background and situational information help define this context and are inevitably shared with all interviewees who take part. Booth states that we cannot describe a world that is independent of our descriptions of us as describers [169]. Hence, there is a need to briefly describe some of my context before going on to discuss the details of the methods used in this study.

To start with, I am a Caucasian, second generation Canadian, Christian, married and well educated male. My parents were both born in South Netherlands, but immigrated to Canada as children shortly after World War II. Like many Dutch immigrants at that time, they were relatively poor, but made up for their poverty with determination and very hard
work. I was born in a small town in Northern British Columbia, but moved with my four older siblings and my parents to Nigeria when I was 6 years old. While I only lived in Nigeria for 6 years, they were indelibly influential years, which I still look back upon with great fondness. I am constantly amazed at the memories and the accompanying nostalgia that slip into my mind when I least expect them, and I often think of the beautiful land and the gentle people, but also of the chaos, filth, and poverty.

Moving back to the fast-paced life of Southwestern Ontario at the age of 12 was very difficult. It was difficult to make friends and also to make sense of the incredible wealth and pace of my new surroundings. My family did eventually ‘fit in’ to our community in London, Ontario and can be well described now as a working, middle class family. I lived in London for seven years before heading off to the University of Waterloo to be trained as a Mechanical Engineer.

I had always enjoyed school, but I loved university. For the most part, I enjoyed the lectures, the assignments, the 6 work terms, and even the exams. I completed a technical Master’s degree in Mechanical Engineering at Queen’s University and after working as a Research Associate for 2 years, began a PhD in computational fuel cell modelling. When I initially started my PhD, it was because of my love for teaching, but just over a year into my PhD, I started to realize that I needed to make sure that I loved my thesis topic as well. After several months of careful consideration, I decided to make a switch and undertake this current topic.

My motivation in my present project comes from several places. First of all, I am personally struck by the social, economic, and environmental inequities and imbalances that seem to dominate our communities, both locally and globally, and want to focus my life on understanding and relieving the injustices as much as possible. A second, and related point: I am not convinced that the high-tech approach that we hear so much about in our government, media, and universities is going to help bridge the gap between the rich and the poor or deal with environmental degradation. Thirdly, in a large number of informal
conversations with graduate and undergraduate students at several Canadian universities, I sense a growing amount of dissatisfaction with the prospects of future, meaningful employment, growing personal debt, and cynicism to the current corporate world.

My spiritual journey for the past 30 years, but especially the past three, is also necessary to understand my perspectives. I consider myself to be an open-minded, liberal Christian, although I acknowledge that this means different things to different people. I believe that an understanding of the spiritual realm is not only essential for individual wholeness, but also for strong community.\(^5\) I see Jesus as a historical person who acted against the dominant social structures that existed in his time and worked in meaningful ways for social justice. Jesus was dedicated to the poor, the disabled and the marginalized. For me, the Old Testament prophet Micah summarizes our existence well: “What does the LORD require of you? To act justly and to love mercy and to walk humbly.\(^6\)”

I am strongly attracted to the concepts of simple living and living in community; I often find myself taking a counter cultural perspective. In a world where issues often polarize people, I like to try to understand multiple perspectives, understanding fully that we must always live with the tensions of division. In short, I am an extremely privileged and a relatively wealthy person trying to make sense of my time on this planet, convinced that there is not much that is important outside of worship, relationship, and stewardship. I am aware that I match every facet of the dominant class as described by Foor [170]: white, male, Christian, heterosexual, married, and middle class.

I am not claiming objectivity with this study, but I do believe my conclusions will point to an understanding in a specific context. I do not think that an objective study is possible given the research question, but the result of this study will be useful and applicable if my biases are considered.

\(^5\)E.F. Schumacher, the author of Small is Beautiful, discusses this as well [38]. Ursula Franklin, another favourite researcher of mine, also speaks a great deal about her spiritual journey and its interconnectedness to her engineering research [10].

\(^6\)Micah 6:8
4.3 Methods

Having described my underlying framework and methodology as well as the source of some of my biases, everything is now in place to discuss how the research was carried out. To begin, the interconnectedness of method and knowledge must be stressed; human interaction and knowledge production cannot be separated.

Qualitative research interviews were conducted between December 2006 and August 2007 in order to obtain opinions, attitudes, narratives, and descriptions of experiences of the interviewees and to interpret the meaning of their described phenomena. The research interviews were structured around the conversation of daily life, but were also designed to be professional conversations.

Much has been written about qualitative research interviews, but most authors agree that there must be a compromise between formalized theories and methodological spontaneity. Kvale advocates for rigorous but non-universal approaches to conducting interview research [171]. To be rigorous, he suggests that as one navigates between the extremes of “no-method” and “all-method,” interviewers must be intimately familiar with their topic, but also with their research tools. For this reason, qualitative research interviews require expertise, skill, and craftsmanship.

Kvale also suggests that two analogies are useful: an interviewer is like both a miner and a traveller. The interviewer is like a miner, as he or she must dig for information within the interviewee — sometimes information that has not been ‘unearthed’ for many years. The interviewer is also like a traveller, as he or she begins an interview, or journey, with some vague goals, but must be prepared for many distractions and unknown turns. The interviewer and the interviewee enter into a relationship and travel together on a journey of learning [171]. These two analogies apply at the level of the individual interview, but also for the entire interviewing process.

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7 Two books on qualitative research interviews, that I used extensively, are by Kvale [171] and Seidman [172]. [173] and [174] were also used, but to a lesser extent.
The Methods described here are based on 7 stages of an interview investigation, as described by Kvale [171]:

1. Thematizing
2. Designing
3. Interviewing
4. Transcribing
5. Analysing
6. Verifying
7. Reporting

This research project was completed in an iterative method, and thus, many of the steps overlapped and were not all completed sequentially. For example, many interviews were transcribed and analysed before all of the interviews were completed. Also, the exact research design was modified slightly as a result of some of the early interviews. In this research, much of the analysis and verification tasks were pushed forward to an earlier stage. Decisions about data collection and analysis strategies were constantly revised during the study. Each day, during the course of this project, I remained cognizant of the emergent design, but also tried to keep the end goal always in sight. Figure 4.2 gives a graphical representation of the iterative process.

4.3.1 Thematizing and research design

The first two steps, thematizing and research design, began when this project was still very much a conceptual idea. Much of the work of thematizing, such as determining the research questions and clarifying the intended purpose, was presented in earlier chapters. The reformulations of concepts and hypotheses, however, have taken place over the course
Figure 4.2: A graphical representation of the iterative method used.
CHAPTER 4. RESEARCH APPROACH

of the project. Many of the decisions have been made on a reflective level, which included
daily journaling and biweekly progress reports. It is easy to say that I have gained sig-
nificant knowledge and understanding during the process which has in turn led to new
dimensions of understanding the subject matter.

Describing the research design is much more tangible. Many pragmatic questions had
to be answered during this stage: From whom will data be collected? How will I select
subjects? How many interviewees do I need? How will data be collected? How will
data be analysed? Can I be sure that I get to know what the subjects really mean? Is a
full transcription necessary? Again, many of the answers to these questions took various
forms during the course of the study, until an appropriate method converged.

First of all, it was decided that semi-structured interviews were to be used — they were
not to be too structured so that ‘travelling’ could occur in the most interesting directions,
and not to be too unstructured so that the necessary ‘mining’ could occur. Again, the
iterative process and interconnection between the steps must be stressed. How I ask my
questions will influence how I analyse and report the data.

The question of ‘who’ was a more difficult question. It was decided to interview both
engineers and non-engineers. Engineering educators, students, researchers, and post-docs
were interviewed, as well as engineers involved in industry and development projects.
Non-engineers included students, development agents and community members from a
variety of socio-economic backgrounds. A wide variety of interviewees were selected in
order to get the greatest variation in attitudes, opinions, and personalities. This approach
was taken because phenomenographic methods work best with a large variation in un-
derstanding [175]. Phenomenographic studies also suggest that everyone in the interview
pool should all stand in a clear and consistent relation to the phenomena under investiga-
tion [164]. In this case, even though not all of the interviewees were engineers, the entire
interview pool was united through their connection to the use of technology for human
development. Interviewees were carefully selected to obtain great variation and quality in
CHAPTER 4. RESEARCH APPROACH

The interviews. Appendix A lists some of the relevant details of each interviewee.

The questions asked in each interview followed the same themes, although were not always presented in the same order. Because of the variety of personalities, the interviews varied slightly — I allowed the conversation to flow in various unrehearsed directions, but made a point of addressing all of the major themes. A set of sample interview questions, or interview guide, is included in Appendix B. The exact wording was adjusted slightly depending on the background and experiences of the interviewee and the dynamics of the interview itself. This practise is in line with suggestions put forth by Marton. He suggests that the interviewer have the interview guide available, but make the interview as open ended as possible, since each interview will naturally take a different course. [176]

I conducted a total of 32 interviews. Approximately half of the interviews were conducted in Canada (17 interviews) and half of the interviews were conducted in Ghana (15). In Canada most of the interviews were completed in Kingston, although some interviews were conducted in Calgary, Guelph, Waterloo, and London. In Ghana, most of the interviews were conducted in the city of Kumasi.

Determining the number of interviews to conduct was another necessary decision. Conventional wisdom suggests that one should interview as many subjects as necessary to find out the needed information. In this study, data was collected until there were no longer significant conceptual variations in the responses. Kvale suggests that the research designer should focus on quality rather than quantity when it comes to selecting the number of interviews, and that more interviews does not mean that the results will be more reliable [171]. Marton and Booth agree with this. They say that phenomenographic studies should always derive their descriptions from a small number of people chosen from a particular population [164].

A final consideration when it comes to research design is to ensure that the research is done with rigour. Rigour refers to the trustworthiness of work and is a technical term for thoughtful planning and diligent execution. This is most often ensured through checking
with the participant and advisory communities for credibility and good practise [177]. To ensure rigour, I passed quotes and in some cases, whole transcriptions onto the interviewees to ensure that I was representing them well. I followed up with each interviewee and gave an open invitation to discuss the conversation a second time. I also passed drafts and presented results to other researchers and advisers who were knowledgeable about my methodology and methods. I heeded the warnings, which usually involved being careful to stick to the methodology and tightening up ambiguous language.

Many other research design questions were tackled during the early stages of the project and will be explained in subsequent sections. The iterative nature of this project should not be forgotten, despite the fact that the following steps are presented in a linear fashion.

### 4.3.2 The interview

My actual data collection occurred during the interview process. The research interviews were designed to resemble a normal conversation or an exchange of ideas, but with a specific purpose and some elements of structure. The phenomenographic interviews were designed to obtain a qualitative description of the conceptual understanding of the interviewee. Kvale states that there is no common procedure for interview research, but that if it is well carried out, it can become an art. He says, “Interviewing is a craft: it does not follow content- and context-free rules of method, but rests on the judgements of a qualified researcher” [171].

While I have conducted several research interviews in the past years for various projects, I still considered myself to be a novice interviewer at the beginning of the project. While extensive reading was useful to gain expertise for the subject matter, research interviews simply require practice. In December 2006, 4 training interviews were conducted

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8The most notable project would be a study of threshold concepts in Mechanical Engineering at Queen’s University, in which 8 full research interviews and 2 focus group discussions were conducted [178].
with social science researchers who had extensive experience in research interviews. Critical feedback gave me the confidence to proceed with the actual data collection. Several of my training interviewees stressed the analogy of an interviewer as a traveller and suggested that much of the learning occurs just through the ‘doing;’ I have found this to be true. Seidman says,

> There are skills — physical, social, mental, communicative — that embody the act of interviewing, but those alone will not determine answers to research questions. For such determinations, budding researchers must learn the skill of comprehension, the complex aptitude and competence of reflection and representation which are perhaps ultimately unteachable by any method than trial and error. [172].

The research interviews were conducted in person, with the interviewee’s consent, and were digitally audio-recorded. An Apple video, 30 GB iPod, in conjunction with a first generation XtremeMac MicroMemo (with 16 bit audio at 44 kHz) recorder, was used to capture the audio data. The interviews in Canada took between 35 minutes and 1 hour and 15 minutes, while the interviews in Ghana took slightly longer, with the longest interview being 1.5 hours. All interviews were conducted in English.

**Pre-interview**

In both Canada and Ghana, the time spent in conversation with the interviewee before the formal interview and audio recording began was extremely important. This time was critical for putting the subject at ease and ensuring a safe and comfortable atmosphere in which to speak. The time before the interview also allowed for a clarification of the purpose of the study and for the interviewee to obtain a pre-knowledge of the the subject matter being investigated, including necessary definitions. The pre-interview included reading the Letter of Information and signing the Form of Consent required by the Queen’s
University General Research Ethics Board (GREB). The Letter of Information and the Form of Consent are shown in Appendix C.

The interviews were always held in an office or a small meeting room with closed doors to assure privacy. During the pre-interview, I also:

- Described the conversation style format that I was going to employ, as one in which anecdotes and tangents were permitted. (In fact, some of the best stories came out of the tangents.) I often suggested to the interviewees that the overall feeling should be informal.

- Suggested that the audio recorder could initially be intrusive but that it would quickly be forgotten.

- Offered a beverage, if appropriate.

- Inconspicuously set up a watch, so that I could subtly check the time without being noticed.

- Ensured that the subject was comfortable and did not have any concerns.

In some cases, the interviewees asked if they could prepare for the interview. In these cases, I would offer a couple of the broad questions that I hoped to cover.

**While the audio is being recorded**

During the interview, I aimed to start with broad and general topics before moving on to some of the more specific topics. I always had my opening question selected prior to the interview. I tried to sit in an open, friendly, and non-confrontational manner, while eagerly anticipating and awaiting the response to my questions. I had to be disciplined to speak with precise language and to ask short, to-the-point questions. I had a list of

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9Freud talks about how he would sit with eager anticipation during his interviews [171].
predetermined issues that I wanted to cover (structured interview), but I also wanted to allow the flow of conversation to dictate the progression (unstructured). I had to constantly strive for an appropriate balance between these two extremes.  

Once the recorder began, I was required to do several things at once. I had to be an active listener so as to comprehend what was being said, plan follow-up questions to verify that I understood the speaker’s point or clear up ambiguous comments, probe to ensure that the interviewee was confident in her or his description, and make decisions about whether or not to move on to other predetermined ideas or to allow the interviewee to continue explaining. I tried to get a sense of the personality of each person I interviewed to interview them accordingly. This was one reason broad, general questions were useful at the beginning of the interview. This is also why being as prepared as possible for an interview is essential. Kvale says,

> The very openness and flexibility of the interview, with its many on-the-spot decisions — for example, whether to follow up new leads in an interview situation or to stick to the interview guide — put strong demands on advance preparation and interviewer competence [171].

In some interviews, I did a great deal of listening and nodding; in others I had to ask many questions to get the information I wanted; and in others I had to challenge the speakers to get them to defend their position.

During every interview, I had a copy of my interview guide in front of me. The interview guide is essentially a list of 5 broad topics, each with 5 or 6 carefully worded questions related to my topic. These questions were designed to build knowledge and understanding, but also to build relationship. I occasionally referred to the guide in order to select the best introduction or follow-up questions, although as I got more experience, I used it very seldom. In some cases, if I knew the interviewee prior to the interview, the interview

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10 As a result of this compromise, my interviews are best described as semi-structured, as mentioned earlier.
guide would be slightly adjusted. The general interview guide is given in Appendix B.

There is no denying that my interview style changed throughout the study. I learned things about the process in every interview, and then logically, took my new knowledge into each subsequent interview. The analogy of the interviewer as a traveller is useful here, as the decisions about data collection were continually revised during the study, much like a traveller might change plans in the middle of a journey.

Post-interview

After the interview was completed and a quick summary was given, the recorder was shut off. I would then give my interviewees an opportunity to add any off-record comments to what they had said. Every single interviewee suggested that he or she did not have anything additional to say, yet conversation would often continue — sometimes for an extra half an hour or more.

After each interview was complete, there were a couple of things that I made sure to do, including:

- Thanking the participants for their ideas and their time.
- Restating the purpose of the study and letting the interviewee know how the information would be used.
- Reassuring the interviewee and attempting to relieve any tension or anxiety.
- Creating an opportunity for any follow-up comments or reflections, if desired.

After saying good-bye, I would take 10 minutes to reflect on the interview content, the interview method, and the debriefing. These reflections were written down in my daily journal.
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Other means of developing understanding: Fieldnotes

While the qualitative research interviews were the primary source for data, I also collected ideas and developed understanding through many interactions, conversations, experiences, and observations. This data was referred to as fieldnotes, a common approach to collecting data in qualitative research [179, 180]. While fieldnotes are not a common source of data in phenomenographic studies, Walsh suggests that other data collection methods are appropriate [181]. I always kept my notebook and my audio recorder accessible during the data collection phase of my project. In addition, I wrote in my journal daily, often several times a day, and tried to take notes as soon after a conversation as possible. Every two weeks, I would go through my journal entries and make a summary of what was learned. Ideas from some of these fieldnotes were incorporated into the thesis, as will be seen in the next chapter.

Many non-research conversations occurred over the course of the past 4 years that have influenced this present work. Perhaps the most significant source of these conversations were the Humanitarian Engineering Discussions (HED) that I initiated and led biweekly at the Integrated Learning Centre (ILC) at Queen’s University. These meetings consisted of the discussion of one or more academic research papers related to the field of Humanitarian Engineering. Typically 8-20 people attended these meetings, and they were sometimes audio recorded (after consent was given). Appendix D gives a listing of the topics or research papers that were discussed.

4.3.3 Transcription

The fourth step in the research process was the transcription of the interviews. I decided to only partially transcribe my interviews. I made this decision because of the meandering conversational style and the relative length of my interviews, but mostly because I did not feel full transcriptions were necessary. I carefully mapped the flow of the conversation,
making notes of the conversation content and the approximate time at which comments were stated. In addition, I fully transcribed comments, questions, and responses that I thought addressed a specific phenomenon for my study. In the end, approximately 50 percent of each interview was transcribed. The most valuable tool that resulted in the transcription process was the interview map, which allowed me to go back to the spoken words during the analysis stage in an efficient manner. Appendix E shows two interview transcriptions.

One of the biggest weaknesses of the transcription process is the loss of information communicated through tone, voice quality, stuttering, and pauses [171]. Using an interview map that allowed me to effectively go back to the digital voice recordings allowed me to overcome this shortcoming of the transcription process. A second weakness is that transcribing misses all of the visual aspects, the influence of the setting, and the body language. I took notes of these things during, and especially after, the interview if I felt they were important. Also, I tried to transcribe the interview as soon as possible after it had occurred; this way the physical interview was fresh in my mind, and I could recall visual information such as body language that I would subsequently note on the interview map.

Upon the completion of the interview, the audio files were easily transferred onto my computer and immediately backed up.

My transcribing routine followed the procedure below:

1. I would listen to the entire interview in full, often using a portable mp3 player, during walks between my home and the university.

2. I would listen to the entire interview in full, but this time taking notes. I would always use a form that I had created in a text editor program which allowed me to enter notes in a location that corresponded to a specific time during the interview. These notes were jotted down under the same broad headings that were used in the interview guide. I would not stop the interview during this stage.
3. I would listen to the entire interview a third time — this time, stopping and rewinding when appropriate in order to transcribe as much as I thought was necessary, taking careful notes. In this stage, I would clean up the file created in the previous step.

Overall, for every hour of recorded audio, I spent approximately 4 to 5 hours in my transcription process. This does not include the additional transcribing work that was done during the analysis stage.

There are plenty of researchers who stress that full transcriptions are not necessary. (See [172, 182] for example.) There are some concerns that not transcribing, however, leads to a premature judgement and exclusion of some data; once a decision is made not to transcribe a portion of the interview, that portion could be lost to the researcher [172]. I overcame this problem by listening to my interviews multiple times on my walks to and from the university after the transcription was complete. This allowed me to make good use of my time spent walking, but also to become increasingly familiar with the nuances during the interviews, which was a great help during the analysis stage. This compares well with the suggestions made by Devault, who defends the practice of working with edited transcripts instead of verbatim records, but also listens to entire tapes as she proceeds with the analysis [182]. In the end, I am sure I spent more time with my interviews than if I had transcribed them in full, but I was able to become more acquainted with the interview, along with all of the voice variations and fluctuations that are missing in written transcriptions. After I completed my analysis and had written a draft of the results, I listened to every interview one more time to ensure that I had been as thorough as possible. This process led to a few changes to the reported results, but these changes were minimal, and I was content that I had not prematurely excluded any data.
4.3.4 Analysis

The next step, the analysis, attempted to uncover the meaning of the interview questions in order to reach some meaningful conclusions. Kvale suggests that “the analysis of an interview is interspersed between the initial story told by the interviewee to the researcher and the final story told by the researcher to an audience” [171].

Analysing something means to separate it into parts and elements. The process of phenomenographic analysis is not an isolated stage; it permeates the entire interview inquiry. It is strongly iterative and comparative and involves the continual sorting and resorting of data and ongoing comparisons between data and the developing categories of description [176].

The analysis involves asking many questions. As Seidman states,

Researchers must ask themselves what they have learned from doing the interviews, studying the transcripts, marking and labelling them, crafting profiles, and organizing categories of excerpts. What connective threads are there among the experiences of the participants they interviewed? How do they understand and explain these connections? What do they understand now that they did not understand before they began the interviews? What surprises have there been? What confirmations of previous instincts? How have their interviews been consistent with the literature? How inconsistent? How have they gone beyond? [172]

Asking, framing, and answering these questions is part of the entire journey, and it is because of these many questions that this study was completed in an iterative process.

As I analysed my data, I sorted information from the transcripts into one of the five concepts covered in the interviews, creating 5 different pools of understanding. (Table 4.1 lists the 5 concepts, which are simply an expansion of the list given in Section 4.1.2). After the data was organized into these concepts, I would read through all of the data in a
Given concept and try to identify different dimensions of variation within that pool of data. (Within each overarching category there exists a variation in the way it is described, and thus, identifying the variations helps identify the categories of description.) Once the areas of variation were found, the categories of description could be determined. As a result, I was able to divide all of the data into the specific category of description and create the 5 outcome spaces.

| Concept 1 | The social role of engineering |
| Concept 2 | Humanitarian engineering as a part of the engineering curriculum |
| Concept 3 | An international humanitarian engineering placement |
| Concept 4 | A local humanitarian engineering placement |
| Concept 5 | Engineering as means to address the root cause of marginalization |

Table 4.1: Humanitarian Engineering in the engineering curriculum: the five concepts in the data.

After the organizing and condensing of the data, the variation in the outcome space for each identified phenomenon was considered and tables were created to indicate inclusive hierarchy. The data was organized so that the categories that were constructed bore some logical relation to each other, as recommended by Walsh [181]. This process was begun long before the final interview was recorded and was repeated constantly as I added new data. I often did go back to listen to the audio recordings, as well as return to the transcripts, as suggested in the previous section. I continued to repeat this procedure until I ran out of data to add, and I found I was not readjusting the categories upon retesting — a stabilized system was found. This procedure was modelled after the instructions for phenomenographic analysis given by Bowden [175]. Again, the analogy of the interviewer as a traveller is useful: upon return home and before telling the story, the traveller carefully considers all of the events experienced. Figure 4.3 graphically shows the steps taken.

I used multiple windows from a computer text editing program to store and organize data, but I found printing out a hard copy of all of my data and literally cutting and pasting
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Figure 4.3: A flowchart depicting the iterative analysis process.
the quotes was the easiest way for identifying and grouping expressed ways of experiencing the phenomenon. I would move the strips of paper around until I was satisfied with their groupings. I often spent a couple of hours in a row simply moving the papers around and testing the logic. Figure 4.4 shows me organizing some of the data.

4.3.5 Verification

Perhaps the largest challenge in the interview stage is to verify the data. This step, like so many of the others, needs to occur at many points during the process. An important initial point is that verification is very much a part of our lived experience. We are all, daily and sub-consciously, trying to verify information that we receive.

The most critical time to verify the data is during the interview process. When I was
interviewing, I was constantly asking clarification questions or repeating the same question with slightly different wording. Leading questions, or even leading body language,\textsuperscript{11} while avoided as much as possible, was deliberately used at times for verification purposes. Near the end of the interview, I would always summarize what had been said and ask the interviewee if he or she had been well represented. The general rule is to continue dialogue on a specific topic until there is only one clear interpretation. This was my approach to data verification.

Part of the verification process is to be aware that our opinions and thoughts are always changing. Several interviewees acknowledged, mostly after the interview, the difficulty in being completely consistent when questioned. A couple of them suggested that their understanding of the role of the engineer in our communities today changes on a weekly basis. For this reason, I, as the interviewer had to be clear, sensitive, critical, and gentle.

Verification of the data after the interview, such as during the transcribing or analysis, is much more difficult. This was typically done with either an informal follow up discussion or a best guess approach. While it is necessary to understand the interviewee as well as possible, the goal is to understand the variation in the pool of meaning [164]. Thus, it is not catastrophic if the perceived description of the phenomenon is not a perfect representation of the idea that was described.

One of the most common ways to verify data is to have several people independently read the transcription and organize the data [175]. Because of the huge time commitment required to do this, I opted to call on the help of research assistants for only the more difficult texts. As I suggested in my discussion on rigour (Section 4.3.1), I verified my data by passing quotes back to the interviewees and presenting results to others in my research group. These were important tasks in the verification stage.

Finally, in his book, Seidman mentions that some interviews are going to go poorly.

\textsuperscript{11}From experience and from the literature, I know that it is impossible not to give yourself away in some manner.
[172]; this was in fact the case in this study as well. Some interviews did not flow as well as others. He continues to say that often the well-polished eloquence is not the most believable data and that sometimes the best information comes from the worst interviews. This was an important point for me to keep in mind during verification. All this being said, it is practically impossible to verify the data with absolute certainty, but this does not negate the value of the data.

4.3.6 Reporting

The final step is about telling the story. Profound or ground-breaking research is useless if it can not be communicated. The final communication will reflect not only the acquired knowledge, but also the journey. In this study, I desired to make some conclusions about engineering education and how engineering students should be taught when it comes to poverty reduction, disaster relief and human development. The following chapters will report on what has been learned as a result of the human interaction, the many conversations, and the analysis.

When the data are presented in the next chapters, it is attributed to one of the anonymous interviewees, interviewed in either Canada (ie Ca1) or Ghana (ie Gh1). When my question, as the interviewer, is necessary for comprehension, it is included, preceded by my initials (JDJV). Words in [square] brackets are added to the quotes to clarify context. Three periods (...) indicate a place where unnecessary words or sentences were removed.

I, as the researcher, have treated this research process in a very non-linear fashion, as has been mentioned many times. The actual writing of this thesis is no exception. My goal from the very beginning of the project was to write several pages of the thesis per week. I stuck to this goal for the most part, except during my three months spent in Ghana.
4.3.7 Ethics

A final subject related to the approach is that of research ethics. The purpose of this work, like that of any useful dissertation, is to improve the human situation. This means that not only does the research have to be relevant and useful to our current human condition, but also that I do no harm to the human subjects involved in the research interviews. Great care must be taken during the recruitment, interviewing, transcribing, analysis, and reporting so that interviewees are treated with respect and no undue stress is brought upon them. The research presented here has passed through the appropriate ethics review boards prior to subject interaction.

In the case of this project, the research ethics can be broken down into three categories:

- Obtain informed consent from all people who are quoted in the following chapters.

- Maintain privacy and confidentiality. This required presenting quotes and dialogue in ways that did not reveal the identity of the interviewee. It also required that I kept my transcriptions, notebooks, electronic data, and computer in a secure place.

- Minimize consequences and harm. In this study, this involved being aware of the emotional state of the interviewees during the interview and allowing them plenty of time to relax afterwards.

The research methods described above gave me a working framework to answer my research questions. The phenomenographic methodology provided me with a useful tool to organize the data. Before presenting this data, however, there is one more topic related to my research approach that must be discussed: the data collected in Ghana.
4.4 Qualitative research in Ghana

Between May 22, 2007 and August 15, 2007, I lived and conducted my research in Kumasi, Ghana. In this study, I desire to make some conclusions about teaching engineers in Canada about their potential role in human and international development, but I believe that a topic that discusses international development issues requires the perspective from a low-income country (LIC).

Why did I go to Ghana?

While one does not usually need to travel far to see impoverishment and marginalization, experiencing poverty in a different culture makes it very real and tangible. (We see the marginalized on our streets so often that we do not always think about it.) Canadians hear the statistics about global poverty so often that we become complacent about it; it is very difficult to comprehend or visualize the billion or so people who do not have access to clean water, for example. I felt that a trip to a low income country could help me put a face to poverty — I would be more prepared to write about the role of the engineer in development if I had had some first-hand experience.

The purpose of my trip to Ghana was threefold:

- To collect data from a different perspective to expand the outcome space.
- To participate in various engineering/development projects.
- To experience life (albeit for a short time) in a low-income country.

Ghana was an excellent location for study for several reasons. First of all, Ghana is considered to be a poor country with many development needs.\footnote{Ghana is ranked 138th on the Human Development Index by the United Nations} Secondly, it is safe to work and travel in, with a stable government and very little of the ethnic tension that haunts...
many African nations. And finally, communication in Ghana is not as challenging as in many other foreign countries because the official language is English. It is probably for these reasons that Ghana has a long history with international development. CIDA (Canadian International Development Agency), for example, has worked with Ghana longer than it has worked with any other African country. As a result there are numerous development projects, many of them related to technology, that have been attempted in Ghana. This made it easy for me to find several development projects in which to participate. I chose to live in Kumasi because the engineering program at Kwame Nkrumah University of Science and Technology (KNUST) is one of the leading engineering schools in Africa and I would have access to many Ghanaian engineers.

I am convinced that my thesis is richer and more complete because of my experience in Ghana.

How has the experience in Ghana influenced my research approach?

The data collected in Ghana, just like that collected in Canada, forms a subset of the pool of understanding. Thus the interviews and fieldnotes add to the breadth of understanding. (Phenomenographic studies can never claim to establish a definitive system — the determined outcome space can only, at best, be a subset of the complete variety of perspectives [164].) There are a couple of important similarities and differences in my research methods, however, that require mention here.

Just like in the Canadian interviews, I tried to interview people from several groups: Engineering educators, practising engineers, development workers, and beneficiaries of aid and appropriate technology projects.

I found that I took more fieldnotes during my time in Ghana than I did in Canada. I lived in a hostel with development studies graduate students and right next door to engineering graduate students, and my evenings were often spent in conversations. I carried my notebook everywhere I went as I always seemed to end up in interesting spots: driving
with Ghanaian engineers to rural communities, waiting with engineering students to listen to al-Gaddafi\textsuperscript{13} speak, and attending social events where development was an important topic.

I had to make some adjustments to my interview guide in Ghana as well, although I did cover the same themes as in my other interviews. On occasion I recorded a verbal consent instead of the signing of a consent form. I did not always use my digital audio recorder for the interviews in Ghana, either. In these cases, I either used an older analog tape recorder or took as many notes as possible, both during and after the interview. In other cases, I interviewed two engineers at the same time. I even interviewed a busy engineer as she was having her nails done and soaking her feet in a mini jet spa.

There are some subtle but important differences in how the interviews were conducted in Ghana, as is always the case with cross-cultural research [171, 183]. I met with several Ghanaians in Canada before departure to talk about possible cultural concerns regarding research interviews. I learned that as an engineer, I must present myself very professionally. In Canada, I often wore jeans or sandals during my interviews, but I found out that any legitimate engineer in Ghana dresses more formally than that, so I dressed accordingly. I also waited as long as possible in Ghana before conducting my first interview in order to better understand the culture.

In Ghana, there are specific norms for interactions with strangers, including not taking initiative in conversation and not speaking openly and directly. Ghanaian people traditionally show great respect to people of authority and I was told by several students that they would never disagree with or contradict their supervisor. It was clear that many Ghanaians have an idealized view of white engineers and this relationship is also necessary to understand in order to make sense of my data. Because of the deference to white professionals, I sometimes wondered if an interviewee was telling me his or her true feelings. (This issue will be discussed further in the next chapter, when I present some data.)

\textsuperscript{13}The notorious leader of Libya.
Also, all interviews contain some elements of asymmetry of power, but this imbalance of power was greater in Ghana. Were some folks unwilling to be critical of my work or to contradict what they thought I believed, even if they felt otherwise?

The next chapter presents the data from both Ghana and Canada, but also includes a section that looks at the data from Ghana separately. Some of these ideas will be revisited there.

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14 The conversation model only goes so far — the interviewer must control the discussion to get the information he or she wants. See [184] for more information on the asymmetry of power in interviews.
Chapter 5

Results and analysis

As citizens we have a privilege to support the South, but we have the obligation to change the North. – Tim Broadhead

An unfettered pursuit of individual self-interest will erode the social institutions capable of protecting the interests of relatively less powerful constituencies just as assuredly as the unchecked pursuit of state or corporate interests will erode the freedom of individuals. – Marullo and Edwards

Whatever steps Africa takes, unless the West radically changes its role, few positive results can be expected. – Gerald Caplan

Attention must now be brought back to the research question: Is there a need or an opportunity to introduce humanitarian engineering concepts into the curriculum? Through a thorough analysis of the data, including both the fieldnotes and the research interviews, some important observations and conclusions can be made to shed some light on this question. This chapter presents an analysis of the data and puts it into context, and the following chapter includes a discussion on the implications of the results.
The information presented in this chapter is broken up into 5 phenomena according to the concepts identified during the analysis stage, as discussed in the previous chapter. The outcome spaces that are presented here are, of course, only a subset of all possible categories of description of the phenomena in question, but there is enough variation to make some useful conclusions. It is also important to note that all 5 of the concepts are interconnected.

The inclusive hierarchies that are presented below were found in the data. In each case, the higher levels of the hierarchy builds on the levels below it. It must be stressed that, as a researcher, I do not claim any objectivity in these hierarchies, but am attempting to illuminate humanitarian engineering practises in a specific context, influenced by my specific biases. I will attempt to make some informed conclusions and recommendations based on insight from a broader way of looking at these concepts gained through the hierarchies presented below. It is also necessary to stress again that no level of understanding is superior to the others, and I do not wish to judge anyone because of their conceptual understanding.\(^1\)

Figure 5.1 gives a graphical layout of the phenomenographic data presented in this chapter.

### 5.1 The social role of engineering

The first issue addressed in every interview was the social role of the engineer, specifically in terms of his or her role with marginalized groups of society. Much has been researched and written on the social responsibility of engineering by sociologists, engineers, and science and technology studies (STS) specialists. It was not my aim to cover this topic in its entirety, but this was always a useful topic with which to start the interviews in order to

\(^1\)It is the described understandings that are structured into a hierarchy and not the individuals. Just because a person’s quote is discussed at a lower category does not mean that that person does not also identify with a dimension of variation at a higher category [162].
Figure 5.1: A graphical layout of the five concepts and outcome spaces.
get the interviewees thinking about technology in human development, and many useful thoughts came out of the process.

The relationship between technology and society was identified by all of the interviewees, but considered very differently, as indicated in the five categories of description listed below. It must be stressed again that of the various ways in which a concept is understood, there is no ‘best’ way of understanding; the hierarchy simply suggests that a ‘higher’ level of understanding usually coincides with an understanding of all of the levels below it. If someone describes a concept using level 4 understanding, for example, they will also be able to conceptualize the previous three meanings. Table 5.1 shows the hierarchy for the first phenomenon.

<table>
<thead>
<tr>
<th></th>
<th>No social responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Responsibility for public good</td>
</tr>
<tr>
<td>3</td>
<td>Engineers improve society through technology</td>
</tr>
<tr>
<td>4</td>
<td>Social improvement through broadening perspectives</td>
</tr>
<tr>
<td>5</td>
<td>Engineering work requires understanding of social location</td>
</tr>
</tbody>
</table>

Table 5.1: The outcome space for the first phenomenon: The social role of engineers

What follows is a detailed description of these categories within the hierarchy, with illustrative quotes from the interviews.

5.1.1 Category 1 - No social responsibility

While none of the interviewees outright suggested that they believed engineers had no social responsibility, several of them alluded to engineering as a neutral endeavor. Some commented that the engineer’s job should focus on the technical aspects and leave the social impacts to someone else. The implication was that technology is neither good nor bad, but depends on the application, and that the engineer should marvel in the joy of the technical challenges and allow sociologists or others to worry about the ramifications.
Some interviewees saw engineers simply as technical specialists whose role is to use technology to solve problems, not to deal with social issues. One interviewee, for example, said

Engineers shouldn’t be looking to solve social problems with technical solutions. They shouldn’t be looking to solve them at all. They should be looking to solve the actual technical problems. Once they get into the realm of social engineering they are just beyond the range of their expertise and we’re just not equipped to deal with it. (Ca10)

This understanding separates the engineer from other occupations and even from his or her role as a citizen. The practice of compartmentalizing aspects of society for the sake of efficiency is sometimes called reductionism.\(^\text{2}\) There are certain benefits (such as increased efficiency) and problems (such as segregation and decline in communication) with reductionism; these will be discussed in more detail later.

A simple extension of this idea is that engineering is useful primarily for personal goals and enjoyment. This is an obvious conclusion once the engineering work is separated from a larger social good. Several interviewees suggested that the role of engineering is to secure employment, make a comfortable income, hold a position of prestige, or help attain a specific lifestyle.

You go to university to do engineering, so what happens is that after 4 years, your dream is to get a good job, getting a good car, getting a big house and having a nice life. (Ca9)

You should assume that tomorrow the world could fall apart and given that, what skills and abilities would you want? ... If I can build things with my

\(^{2}\)Reductionism is a term used in many fields including philosophy, science, religion, and linguistics and describes the practice of analysing and describing a complex phenomenon by reducing it to the interactions of their parts or other simpler, more fundamental things. With reductionism, the account of a complex system can be reduced to the accounts of the individual constituents.
hands and I can build things with my mind, well, I’m pretty much set. Then I’ve secured my position in any society and I’ve got a portable skill set. ... I want to do this so that I can have legitimacy and a simple lifestyle. (Ca10)

In this category, the satisfaction of solving the technical challenges and the financial security that goes along with a job are ends in themselves. That being said, the professional engineer is called upon to make decisions about whether or not their tasks adhere to a specific code of ethics. Thus, an engineer must have some understanding of the larger context in which her or his work exists. The following quote, however, suggests that this responsibility is sometimes ignored.

Engineers are called to a certain ethic, (pause) but much like the soldier they constantly need to decide between doing what is right and following orders. They are told, ‘Build this. Do that.’ And then the engineer, is like, ‘Wait a second. Oh well, big fat pay check. I’m just going to do it.’ (Ca12)

In Ghana, engineering is a highly respected career, and many conversations with engineers indicated that going into engineering was a good way to secure a respected position in society. Of course, the way any concept is understood is influenced by cultural and generational conditions. One Canadian engineer, who had been practising for over 20 years, suggested that only recently was he able to see outside of this level of understanding:

I see now that engineers have a responsibility to community. But for a long time, I did not see it. I just thought that engineers are to be told what needs to be designed and built. (Ca11)

In many conversations and fieldnotes, including an unpublished, informal survey of Queen’s University students on Humanitarian Engineering, many respondents confessed

\footnote{James Miller’s thesis discusses this survey in more detail [185].}
that they went into engineering because of the job prospects. However, according to the survey, as these students got closer to graduation, they often indicated significant discontentment with the potential for satisfying job opportunities, despite the wage earning potential. With this thought, coupled with the increased interest in engineering and development, perhaps, the idea that engineering has no social responsibility is becoming less prevalent. One interviewee discussed exactly that:

JDJV: There are people who argue that the engineer needs to focus on technical issues and should leave the social impact to others. What do you think of that?

Ca5: The reality is that this perspective is an old and dated one. I think that if you were to look at any engineering program today in North America and across Europe, they are trying to make big goals in getting rid of that mystique and incorporating social stuff.

Regardless of what the engineers themselves think, there is also a public perception that the engineer is more interested in the machine than in the user, as suggested in the following quote from a non-Engineer interviewee.

I do not know whether [engineers] take into account the people. They are more worried about the structure and technology that they are building, and the efficiency. (Ca15)

5.1.2 Category 2 - Responsibility for public good

In this second category, the engineer is seen as having a responsibility for the public good. The engineer must keep this in mind throughout the design process and does not have the luxury of just focusing on the technical challenges. This category was most often described using safe and good design, and useful products and infrastructure as examples.
Before giving examples of this category, it is useful to clarify what is meant by the *public*. This is not a straightforward task as the answer will depend on the situation in question. Ideally, the public refers to all people involved or who should have access to a particular project. Often a technology can help one group of the public at the expense of another group;\(^4\) however, in these cases, defining the *public* is ambiguous. This ambiguity could allow the engineer to ‘define’ the public as whoever benefits, which results in a useless discourse. If the engineer is seen to be responsible for the larger public good, he or she must attempt to make the benefits of the technology as inclusive as possible.

Turning to the interviews: there were many quotes given by interviewees about the role of engineering for public safety and the greater good. Here is a small selection:

> Why am I an engineer? Engineers are about public health and safety. That is what engineers do. We should improve public health and improve public safety. That is what we are all about. It’s my job. (Ca5)

> A lot of the emphasis, in my engineering education, was on protecting the good of the public. As a civil engineer, make sure you are not incompetent. Make sure that your designs are going to work. Make sure that nobody’s health or safety is going to be endangered by a poor design. (Ca8)

> Like doctors, engineers are committed to public good. They need to be ethical and moral beings. (Ca11)

> Engineering is about providing facilities for the community. So, it is definitely connected to the community. (Ca9)

The connection between engineering and community mentioned in the last quote is critical, although, much like the word *public*, the word *community* can be quite ambiguous.

\(^{4}\)This practise is seen when cities plan roadways or parks, for example. In our globalized world, benefits to one community may be a detriment to a faraway community, unbeknownst to the majority of the beneficiaries.
One of the implications of engineering within a capitalist society is that engineering services often benefit only those who can afford those services. The next quote captures this problem and points to the question of who should gain from the work of engineers.

All engineering must be for a greater good and for humans, but right now, engineering is for those who can pay for it. So often, those who cannot pay for it need the services the most. (Gh5)

In order to provide these services, engineers must communicate clearly. Communication and interpersonal skills are required to relate to people from the many other sectors of society, especially lay people. Many of my conversations suggested that engineers need to improve their ability to communicate so that they can better fulfill their social role of appropriate and safe design. Several organizations who routinely work with the engineering profession suggested that the engineer’s attitude and communication skills are often barriers to getting things done. An engineer’s passion, attitude, and motivation will help shape his or her ability to contribute to the public good.

The engineers are designing great things for our benefit. ... But, engineering mistakes [and disasters] are always glaringly obvious. And this is not just about numbers and calculations, but it is about caring and beating hearts. As an engineer, if you really care and if you really have passion, you are going to make sure that the levee is really going to hold. (Ca12)

Although the interviews were focused on social issues, environmental concerns repeatedly came up. This is understandable, as it is often impossible to separate environmental and social concerns. It was brought up in many conversations that an engineer’s responsibility in good design means sustainable and environmentally sound design. Several engineers interviewed suggested that improving the efficiency of their specific technology was an important contribution that they could make.
Recently I realized, for one thing, this whole issue of climate change and sustainability is an engineering issue where again most of the solutions are relatively known, although there is a lot of room for improvement, but it seems like engineers need to engage in social discourse more. (Ca11)

While many identified with the idea that engineering has a responsibility to the public good, several interviewees suggested that engineers sometimes twist this responsibility so that they can do what they really want to do.

We all know, theoretically, that the engineer exists for the benefit of the public. That is what the documentation says. What Rudyard Kipling tries to firmly engrain into our heads [in the ritual of the Calling of the Engineer]. So we all have some noble aspirations of benefiting society. That said, we all go into engineering because we think it is fun or because we think we are going to make money at it. ... After the fact, we say, ’sweet’, there is this noble calling alongside all that that I can use to justify my existence. (Ca13)

We often pay lip service to engineering-service to community. When we look at engineering professional practice and so on, it is full of nice phrases. But in reality, when engineers get jobs, they’ll do whatever to get the wage. ... We could do deconstruction of these phrases that our professional commitment is littered with, and analyze how these potentially useful and noble goals are being routinely shoved aside with impunity. Maybe it is a good start to latch on to what is on paper already. (Ca11)

5.1.3 Category 3 - Engineers improve society through technology

In this third category, engineering is seen as an important tool in social improvement through the development of technology. As opposed to the previous category, where engineering was seen to exist for the benefit and safety of society, engineering in this category
is seen to enhance and strengthen society.\textsuperscript{5} The following quote captures exactly that.

\begin{quote}
I think engineering, as I understand it, is to try make life easier, generally, for everybody. ... It is part of the job that the engineer is supposed to do. They should do whatever to make life more comfortable or to ease the human burden. (Gh6)
\end{quote}

A number of interviewees described engineering as an important factor for economic growth and the production of wealth, which in turn was described as necessary for poverty reduction. The social role of the engineer is to use innovation to maximize positive economic impact, trusting that the social impact will follow. In this way engineers can improve society and raise standards of living.

\begin{quote}
It is a good thing that an engineer try to do good things for their company so their company prospers and they have lots of employees and those employees prosper and pay their taxes and do all those good things for society. (Ca14)
\end{quote}

While this understanding was described in several of the interviews conducted in Canada, it was most prevalent in the discussions in Ghana. With so much dialogue in Ghana about development, modernization, and ‘catch-up,’ the engineer has become a very important symbol of hope and future prosperity, not only for the individual, but for the nation. The argument is that economic growth can help alleviate poverty, and engineers are necessary for the infrastructure that is necessary for economic growth. Distribution of the wealth that results from growth in a fair manner is often difficult, but in most discussions it was acknowledged that, while it is not a perfect idea, it does raise standards of living.

Through the development of technology, engineers can provide solutions and technical knowledge to their own and other communities. Engineers work through problem

\textsuperscript{5}The discussion about the ambiguity around the words \textit{public} and \textit{community} in the previous category could be repeated for the word \textit{society}. 
solving algorithms to find solutions that alleviate problems; this is the story behind many labour saving devices. This is another way in which engineering leads to improved living conditions.

From my perspective as an engineer myself, I think engineers have huge roles in terms of development of the human being. When it comes to hard core engineering, designing of machines, designing of bridges, it all is supposed to facilitate or improve the quality of life. (Gh7)

An engineer is trained to make something. (pause) Above all, you don’t want the engineering student to be diluting themselves. If there is something they could make or a service they could provide to alleviate those problems, then it should be brought to their attention. Maybe what that means is to provide that technical knowledge to some place where it is lacking. (Ca13)

The focus on this category is on how technology can influence society for the better. There are, of course, negative influences of technology, which are very difficult — often impossible — to predict. That being said, the engineer must have a thoughtful design process that attempts to predict how technology will shape both local and global communities as well as future generations. This can be done with a thorough impact assessment. Too often, technological impact assessments are done after the main decisions are made and the assessment is formed so that the desired outcome is supported. Thus, a thorough design process must be accompanied by integrity and intentionality.

This task is challenging in the globalized world where so many people-groups are interconnected through travel, communication, and trade. These complex interconnections are also what make comprehensive technological impact assessments so necessary. The following quote captures this idea.

Whatever you do you must work to make the world a better place. Now
it is clear, that it is not enough just to make your own country a better place.
Everything has become more global — like global warming. (Ca9)

For many in the engineering profession, there is confusion over how their work leads to a better world with both improved relationships and decreased suffering. There are enough life experiences to indicate that improved economics or technical advancements do not necessarily lead to the desired social improvements. Engineers want to work for a greater good, but it is not easily apparent. The next two quotes captured this inner tension.

JDJV: In your opinion, what is the social role of the engineer? Do you think the engineer has a social role?
Ca8: You sure hope so. Your designs are supposed to be safe and benefit the city or whoever. It is definitely not something that always jumps to your mind when you are doing your courses or when doing your job, but there definitely has to be something behind all that stuff. ... There are a lot of driving factors behind why people do engineering. Like “Am I just there to make a lot of money” or to strive to be the best in the corporation. That can be one way of looking at it. For myself, I hope that there is a greater good to the work.

We’ve got a lot of people who are highly educated, who think that engineering research is cool and their efforts are going into marginally environmentally relevant research. They are good people. If they could, they would find something with more direct impact, but they don’t know how. Their skill set would coincide with saving the world. (Ca13)

This category has presented engineering and technology as something that influences society and has a great potential to improve the human condition. Figure 5.2 is a simple graphical representation of this category.
A final quote captures several of the ideas presented for this category. An interviewee used the example of the cell phone in Ghana to illustrate how technology can lead to social exclusion. Students who cannot afford a cell phone are denied an important way of communication. As a result, almost all students have a cell phone, even if it results in greater financial strain. The hardships are a necessary step on the path towards progress, according to this interviewee:

Technological change always seems to cause social and political problems. When the change is so fast, the problems are large. But this is the cycle — politically minded people create social change to fix the problem. ... This is part of our progress as a planet. (Gh6)

5.1.4 Category 4 - Social improvement through broadening perspectives

In this fourth level of understanding, engineering is seen as a part of a much broader picture, and it must be understood as such if engineering is to be used to improve life in general. This is a challenge to our reductionist tendency. Also, if the last section was best represented by Figure 5.2, then this category is best represented by Figure 5.3. This category suggests that technology and social order are constructed simultaneously and influence each other greatly. In other words, technology and the social world are co-produced and engineers must be aware of this; they must work in a social context because not only is society influenced by technology, but it is intimately connected to technology.
There were a significant number of comments on how social awareness influences design. The following set of quotes justifies the feedback loop from Society back into Technology.

Being socially aware results in good design. (Ca7)

I think if you don’t engineer in a social context, you will be an inferior engineer. If you don’t understand where your particular skill set fits, if you don’t anticipate what the particular project, product, or service that you are providing is put within the context, you are very likely to miss the target. (Ca16)

The engineer has a responsibility to society. And the society is made up of people. And each culture is different. So an engineer needs to be adaptable so he or she can modify whatever they do to fit the context, but if you do not take the context into account, then we will not achieve what we want to achieve. Then, you create more problems. (Ca15)

Science is objective. Science exists without any particular social or cultural context in that it is objective natural law. But engineering is the application of science to serve some human need. ... If an engineer rashly applies science without a consideration of society, it is really rare that he or she will create something that is a benefit to society. (Ca2)
Design is influenced by one’s own social view and social position and it is important to be aware of that. I think you need to maintain responsibility with what you are designing. I guess there is a lot of talk that technology is neutral, but I don’t believe that. I think that technology is a very political thing and it is important to remain aware of that. I think a lot of times people aren’t aware of the way their own biases play into something and I think it is important to at least remain aware of that. (Ca4)

The notion of the simultaneous construction of society and technology is not a new one, by any means. There is evidence that it has been the predominant thought for much of history, and reason to believe that today’s engineers must adopt this more holistic way of looking at technology and society. The following quote looks to the ancient Greeks to make this point.

I think the idea that engineers are merely technicians is an unfortunate way of thinking that I think a lot of people have. ... The ancient Greeks were very concerned with the relationship with what they called tekhne, where we get our word technology, and the larger social, ethos, that informs what that technology is for and that those two things were inextricably connected, right? This was very clear to the ancient Greeks from reading their history. So you could have something that was technologically possible, but socially and ethically a bad idea. It was possible for the Greeks to think about that in some real sophisticated ways. I think it is harder for us to think about that now. So, I think that empowering engineers and working with engineers to help them understand that technology isn’t neutral. It is always deployed in a place by someone. I think it is a really good idea. (Ca1)

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See [83, 186] for example.
CHAPTER 5. RESULTS AND ANALYSIS

The following quote from an interview in Ghana suggests that the need to change from a more segregated way of thinking is also present there.

JDJV: Some people say that engineers are to focus only on the technical aspects and someone else is responsible for its social impact. What do you think about that perspective?

Gh7: I think in the past, that approach existed and we realized that some projects did not work. Some projects failed in the field because of this approach. So, in the engineering disciplines, social issues are also integral in some of the courses. There is a shift, and I know that many students try to take courses in general development or appropriate technology courses. There is a real social and economic aspect so we don’t only focus on the physical and we have a broader thinking.

Challenging reductionist thinking and breaking down the structures that were built in support of reductionism was a common theme in many interviews. The following quotes add to those before, giving a rich collection of thoughts on the need for the engineer to embrace broad thinking and to break through confining professional fetters.

We like to build fences around occupations. ... We’re losing view of the big picture in both time and space. Now that we know so much, we’ve lost view of the whole thing. (Ca1)

Our society has become specialized. If we break down specialized society, people could tolerate a lot more and we’d be more solid human beings. (Ca7)

In our society, we have had remarkable changes to how we live our lives because of technology and whether or not that is deliberate or not, it is hard to say. But it is undeniable. Now, is it the role of the engineer to know so? The
way our society is headed and is maintaining the philosophies of modernity that our societies so strongly hold, it would not be. We live in a reductionist, imperialist society. In that view, it is not the engineer’s role to be concerned with the societal impacts. His (sic) role is to work within a well defined discipline. And we’ve benefitted greatly from this view of the world. However, I think we’ve reached the end of the good reductionist train and now we are suffering the problems. (Ca2)

One Ghanaian interviewee pointed to the more industrialized societies as the source of reductionist thinking and suggested that this thinking was not conducive to a more satisfying way of living in Ghana either.

I think that as your societies have become more industrialized and more segmented — engineering versus social science versus political science and so on. In the societies where we have a lot more, it is a bourgeois view to say that engineers should worry about innovation and mathematics and the science and the physics and leave the applications to social scientists. I find that it is a very bourgeois view because then, it makes engineering very stale and those who come to engineering in this part of the world want to solve practical problems and they are terribly disappointed when they come into here and are inundated with calculus and Laplace Transforms and all these kinds of stuff. (Gh9)

It has been acknowledged that there are many benefits in having workers working in a highly specialized and prescriptive fashion. The breadth of our technical accomplishments would not be possible without this mindset. But we now have the luxury of reflecting on where we have come from and where we want to go. The following two quotes suggest that a more integrated approach could bring a shift in focus and perhaps a more equitable and fulfilling way of life.
It’s not that we’ve achieved everything that we could achieve but that we recognize that what we are doing is not bringing us to the place where we want to be. More freedom, more time, more flexibility. In fact it has brought a whole new series of problems. This is why engineering needs a shift in focus. (Ca11)

Engineering needs to be engaged socially. This is not the paradise we expected, or even if it is for some people, it is a very, very precarious paradise, where everybody deep down knows it is not sustainable. (Ca11)

The idea of humility was a constant theme in the interviews, and was often discussed along with social justice. A reductionist society often values some people more than others. Humility is necessary to counteract this attitude and thus, is an important trait for broadening perspectives.

We’re all just people. ... The kids doing trades are just as bright. There’s nothing special about engineers. We’re just people. This fallacy that education will make you a more functional, able person is what perpetuates the elitism and superiority that you see. (Ca10)

5.1.5 Category 5 - Engineering work requires understanding of social location

The final category of understanding of the social role of engineering builds on the previous categories. Social improvement comes not only through thoughtful design and the broadening of perspective, but also through a deeper understanding of the limitations of engineering through the engineer’s understanding of his or her social location: in other words, his or her position in the current corporate/industrial/economic/political system. While there is much potential good in their work, engineers must realize that if care is not taken, their work can also be used to dominate, exploit and oppress. Several interviewees suggested that there is much evidence of exactly that happening.
Unfortunately, engineers choose to do the dirty work for the corporation and institutions. (Gh6)

Technology can be part of the solution, but the problem is that often technology is used to serve the interests of governments, corporations and others, so it is not necessarily going where it is needed the most. ... The university should be less supported by corporate interests, and less tied up in corporate interests and is more for common good. Although it is acknowledged that the university is not that neutral. (Ca4)

One interviewee who was struggling with an employment opportunity discussed inner tension associated with his decision.

I would be another cog in an economic machine. I probably wouldn’t even produce anything, I’d help more with demonstration units to volley their stock. And that’s what their board of directors wants — their stock value volleyed. I think that’s true for the vast majority of engineers — they are working for the corporation. You shouldn’t lie to yourself. If you’re going to work for the corporation, you are working for no one but the corporation. You are working for people who are cognizant of the bottom line. ... They are there for the purpose of making money. I do think that’s tragic, but that is the structure of the economy that we’ve allowed to exist. The people in power, the leadership positions, have all allowed this machinery to assemble and they cater to that machinery’s will. The engineers have always been soldiers, it’s just that the army they are working for are like that. (Ca13)

Several interviewees identified the challenging world in which the engineer must exist. There is a desire for the engineer to work for the benefit of all people and not to further harm precious cultural or environmental entities, but it is not easy to find employment that allows an appropriate balance.
Most engineers are engaged in what I would call frivolous engineering. ... In reality, when engineers get jobs, they’ll do whatever to get the wage. So they are essentially the mercenaries of the business world. (Ca11)

Currently the engineer is a tool of the corporation and the profit and money making machine. He or she is an obedient soldier for the capitalist way of life. They are focused on domination and oppression and generating wealth. ... It does not have to be this way — engineers have very useful skills, but need to get outside of this dominant discourse. We need people with engineering-like skills for building strong communities. (Ca6)

Technology could take a role [in social justice.] ... We have an obligation to teach engineering students and to expose the truth. In a way we must be activists. (Ca4)

There is hope in this message of frustration: exposing the truth and building strong communities are two excellent responses of a useful engineer. We are usually very aware of our geographic location, but it is necessary to have a deeper understanding of our social location: how our social interactions influence the social interactions of other people in our own neighbourhood and around the world. While initially, these responses can be daunting, there is freedom in truth and the deeper understanding can encourage a desire for social justice and good change.

The next section is about engineering curriculum, but is deeply connected to this section; it is necessary for engineering educators to instruct their students about social location. A final quote of this section captures this idea and leads into the discussion of engineering education.

Gh1: Engineers must understand how their work influences others and often results in great imbalances. But so often the engineer is powerless. They are controlled by their employer, but they must understand.
JDJV: So how can educators make sure that young engineers are aware of the consequences of their work?

Gh1: I don’t know. But you have to bring it up.

The hierarchy of ways in which the social role of engineering is understood is important for this thesis as it points to both how engineering education is understood and how humanitarian engineering could fit into the curriculum. These are both key ideas for this dissertation and will be dealt with shortly. This section also identified an important conflict in the pool of understanding: the ‘neutrality’ of technology. This issue will be addressed again later.

5.2 Humanitarian engineering as a part of the engineering curriculum

After the opening session on the role of engineering, the dialogue was allowed to go in many directions, depending on the dynamics of the conversation, and there was no set order in which the remaining four topics were discussed. Often, however, the second concept covered involved the engineering curriculum. This topic lead to impassioned discussion, and it is significant to note that not one of the interviewees suggested that the educational system functions in the optimal way. Everyone had an opinion on how engineering education might be adjusted. While the non-engineers had many comments, the most poignant responses come from the engineers whose careers are most closely connected to education.

The specific goal was to discuss how the engineering curriculum could be adjusted to increase (or decrease) the amount of material related to human development and humanitarian engineering. Again, there were many ways in which this was understood, and five categories were found in the data. Table 5.2 shows the hierarchy for this second phenomenon. Recall that in all of the interviews, humanitarian engineering was defined\(^7\)

\(^7\)See definition in Chapter 1.
Before the interviewees gave their descriptions.

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Table 5.2: The outcome space for the second phenomenon: Humanitarian engineering as a part of the engineering curriculum

Of the five concepts discussed in the interviews, the largest percentage of time was spent on this second topic. The majority of this time was spent talking about the interviewees’ conceptions of incorporating humanitarian engineering into the curriculum, but we also discussed other issues including the extent of some of the problems and suggestions on what humanitarian engineering should be in practice. Several of these related topics will be explored later, but for now a more detailed description of the categories within the hierarchy follows.

### 5.2.1 Category 1 - A good idea for those who are interested

In the first category of the second phenomenon, humanitarian engineering in the curriculum is seen to be potentially good for addressing the needs of the marginalized, creating awareness and attracting students to engineering. While humanitarian engineering was typically seen as an inherently good idea, it was stressed that it should be introduced only for those who are interested. Some of the interviewees who demonstrated this level of understanding discussed a single elective, while others considered an entire program, but in all cases humanitarian engineering was understood as something that should be directed towards those who are interested. The following quote stresses the choice of the student.

JDJV: What do you think of a humanitarian engineering program? Does the
engineer have a role in ... helping the marginalized, the poor?

Ca14: Sure, if they choose to. We have engineers who become politicians, (pause) we have engineers who choose to do exactly those things. The individual engineer should choose how far they want to go in that direction. They should be made aware that that direction is available to them as a career, if that is what they choose.

Another interviewee said that humanitarian engineering should be offered because there is interest from the students.\(^8\) The drive in curriculum change often comes from student interest. This attitude implies that curriculum should mirror the student’s desires.

It is what the students seem to want, so they should have access to it. (Ca5)

There was significant enthusiasm for humanitarian engineering in interviews, discussions, and several unofficial surveys. Many suggested that the curriculum change was appropriate because of the interest. In one of our formal Humanitarian Engineering Discussion meetings, a non-engineer stated, “I would have gone into Engineering, had I known about this.” In an interview, an engineering student said,

I probably wouldn’t have gone into Engineering if I didn’t know about how engineering can be applied for human development. (Ca3)

This observation seems consistent with what is happening at other engineering schools across Canada. A first year module on engineering in international development was discussed in one interview with an engineering student from another Canadian university. The interviewee said that the module was immensely popular with a significant waiting list:

\(^8\)The interest in humanitarian engineering seems to be growing across Queen’s campus, based on discussions with many engineering students over the past couple of years. In a recent informal poll taken of second year Civil Engineering students in September 2007, 34 out of 110 students suggest that they came to Civil Engineering because of its connection with the humanitarian engineering initiative at Queen’s.
We can back this up with student interest and testimonials and the sheer volume of people who are interested. (Ca3)

The common view in the quotes above suggest that, because there is interest in humanitarian engineering, it should be available to the students. Some of the same interviewees who talked about the interest also argued that it was not for everyone.

We can’t expect the whole class to do this. (Ca9)

Not everyone will want to do this, and not everyone should. (Ca3)

While it is conceivable that there are people who feel that there should be no focus on marginalized communities within engineering education, none of the interviewees held this position.

### 5.2.2 Category 2 - All students should be exposed

Not everyone agrees that humanitarian engineering should only be for a few who are interested, but it was a first way of understanding that everyone could identify with — and the next level builds on it. In this next level, humanitarian engineering is seen as something that everyone should be exposed to, even if it is only in a small way, such as a single course or module. It was argued by many that if humanitarian engineering were offered as a separate entity, the rest of the engineering program would perhaps be viewed as non-humanitarian. To these interviewees, humanitarian engineering must be seen as an underlying principle and not a distinct option.

In addition, the course content is essential, and many students on their own would not, perhaps, choose to participate. Often students are encouraged to go into engineering because of their skills in math and science. These students are not necessarily drawn to the social dimension of engineering. Stressing that engineering is primarily about math and
science perpetuates the stereotype and might be enough to keep students from recognizing the social dimension.

Sometimes all it takes is one course to change the attitude in a whole faculty. But we must make this one course to be taken seriously by everyone. (Ca4)

In a rapidly changing world, there is growing interest from the students who are looking for a deeper understanding of the setting in which they will apply their engineering skills, according to some interviewees. Students who may not be initially interested may find a great deal of meaning and motivation in a humanitarian engineering curriculum. Having humanitarian engineering curriculum as an option may keep students away who would otherwise benefit. This next quote suggests that there needs to be something to demonstrate the need for engineering education to address human development.

JDJV: Is there a need to talk more about social justice, poverty reduction, human development in the engineering curriculum?

Ca8: I think so. I’m not sure that all students would be totally excited about that, but there’s definitely got to be something. That’s where a lot of students are at, too. Some people don’t care at all — they are there for fun and to eventually get a job and make money, but a significant percent of the student population are really wrestling with these issues and are really interested in what are we ultimately doing.

Engineering students require an awareness of the social issues that surround marginalized communities, especially in light of technical changes. One interviewee who was born in a low-income country talked about how development and wealth has only reached a minority of people and saw great value in creating awareness through a humanitarian engineering curriculum:
It can make students aware. In [my country], everyone knows about the homeless people, but the tendencies are for people to get selfish and forget that. We just focus on my development of my family and stuff. In the university, the lecturers are sort of our role models and so if they can tell you to don’t only think about your career development. ... It is good for students in the whole world to have awareness — especially in a developed country. In developing countries too, they forget these things. Their goals are just to go up and up and they forget the poor. ... Many people here [in Canada] haven’t seen real poverty — the students would be shocked. I think that seminars can be part. (Ca9)

This category is well characterized by the fundamental stage of learning and awareness. A humanitarian engineering curriculum can result in engineers thinking more about their impact on marginalized communities within Canada and overseas, and will, ideally, influence how they use their skills.

Another idea connected with humanitarian engineering as something necessary for all students was alluded to in a quote by Ca14 in the previous section: students need to see a variety of places where they could apply their skill. “[Students] should be made aware that that direction is available to them as a career, if that is what they choose.” 

Finally, one interviewee suggested that using engineering to help a community in need is very Canadian, part of our heritage, and thus should be an important part of our education. He pointed to the Canadian Heritage commercial that depicts the story of two Canadian engineers who developed a simple pump for an African community by observing a Canadian Mennonite farm. After reiterating the story in the heritage commercial, he said the following:

That story is told in context of Canadian heritage. [It is] part of Canadian’s

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9Emphasis added.

10See [187] for more on this heritage moment.
ingenuity, part of Canada’s cultural diversity. ... So we’ve got a public perception and it’s part of our national identity. In a very basic way, we can talk in an engineering curriculum about those kinds of applications of technology. ... So I guess I have to say, ‘Yes, I think [humanitarian engineering] is a good idea for all students.’ And there is, to me, some indication that we already think it is a good idea to talk about what the point of the technology is. (Ca1)

While there is a strong sense that human development should be introduced to all engineering students, it is not currently a priority in the curriculum. The next two quotes show that while humanitarian issues do not receive much attention, other non-engineering topics, such as economics and business do get discussed. Both quotes imply that adding a humanitarian engineering philosophy to the curriculum would be a benefit.

JDJV: Does this mean that there is a need for change in our curriculum?

Ca11: Yes. It’s a big yes. I would argue that we already had a big change. Now there is a significant business component in our curriculum already which is certainly not engineering and if we can have that, then we can certainly have a more social justice component. And engineering responsibility.

Ca13: My Mechanical Engineering courses were speckled with realistic quips, like, ‘You’re not going to tell your boss this’ and there would be chuckles throughout the class and there would be reminders always that an engineer has to be cognizant of the bottom line. I think that prepares students to be cogs in an economic machine.

JDJV: So you are saying that engineering is about teaching the dominant discourse?

Ca13: Yeah.

JDJV: Are alternatives offered?
Ca13: No they are not. I think it has been that way for a while. We educate people to look at high tech. ... There has always been an emphasis on science, technical proficiency, or making money. There is certainly no emphasis on any humanitarian issues or environmental issues unless they are tangential to those other categories. In this faculty it is not a category worthy unto itself.

5.2.3 Category 3 - A useful step towards broadening the curriculum

This next category is, again, an extension of the previous one. Humanitarian engineering in the curriculum is seen as a useful tool to broaden the curriculum if the right balance can be struck. Engineers need not only objective, but also subjective tools. This is important, not only because it can help create a more holistic person, but also because engineering requires both analytical and creative thinking.

Ca16: There needs to be a broad awareness. The more aware the engineer is, the more prepared they will be to help deliver a solution. We encourage our engineers to take interest in areas beyond their discipline.

JDJV: Can we encourage that in the curriculum?

Ca16: I think it is an absolute must. I think to just crank out students who are technically competent without being able to integrate that with the application or the overall solution that is being provided, does not bode well.

There is much discussion about training engineering students to be well-rounded citizens, but a balance must be found between specialization and breadth. Engineering education should be about the development of the whole person, but at the same time, students should not sacrifice a solid engineering skill set.

The term ‘multidisciplinary’ and other modes of ‘type 2’ knowledge production were discussed in many interviews. One impetus for broadening the engineering curriculum is to help engineers understand the challenges in the many disciplines around them. People
in the university environment call attention to the dangers of the ‘silo’ or ‘bore-hole’ effect, where students or researchers are so immersed in their own work that they have a very difficult time relating to other areas of research [131].

Not only is it necessary to be more multidisciplinary, but [a humanitarian engineering program] will fail without it. ... Engineers need to be deep in their science, but also broad across society. (Ca2)

There is a huge need for our students to be involved in more multidisciplinary work. We can argue that many of our real problems that we face are a result of not working together more and many of the crises we face can only be solved with multidisciplinary work: global warming, population explosion and dwindling resources, terrorism. (Ca17)

While there was much discussion about educating well-rounded engineering students, there was a parallel concern over being too focused on non-technical content. A concern for the right balance in the curriculum was voiced by many. In one of the formal Humanitarian Engineering Discussions, one participant was concerned about their skill set if their engineering education focused on humanitarian engineering. “I want to make sure that we have enough skills to be employable afterwards. If I go overseas and then come back and have a family and a career, I want to be able to work in a company and I want to make sure we have enough skills to be employable afterwards.” Another interviewee:

I’m concerned that the program will not be technical enough [if we add social concerns to the curriculum]. We’ll have lots of engineers who will not be competent. (Ca3)

We seem to be cutting back on the technical stuff so much. We spend too much time worrying about group work and that kind of thing and we drop
the fundamental technical stuff through the cracks. We can’t start adding more social science courses if it means dropping more foundational courses. (Ca14)

I would hesitate to turn an engineering degree into an arts degree. I would hesitate to bring an excessive amount of humanities and politics and literature and languages. All those are good things. While we want our students to understand those things, engineering is still an applied science degree. ... We just have to recognize our role on the team. The phrase, jack of all trades, master of none, comes to mind. (Ca13)

It is easy to say that the key is in finding the right balance; it is difficult to say what that would look like. The following quote should be read in contrast to the previous ones:

It’s been a shortcoming of our engineering education, that we’ve disregarded the social, economic, environmental, political, cultural impacts of our technologies. And we’ve suffered huge consequences because of it. (Ca2)

Ca5: We need to expose our students to more basic arts and sciences. Students need to have the ability to take more general knowledge of the world and critical thinking — so they can explore their own feelings about the world and social justice and CSR\textsuperscript{11} and globalization. They need the opportunity to do that and they need more choices. ... We need to bring up some of these issues early on in their education and we need to push it continually. Reinforce it continually. Keep pushing it.

JDJV: How do we maintain technical competency and a well balanced person? Deal with trade off?

Ca5: Why spend so much time on the technical details? We want to be training problem solvers who can be able to identify the problems. What are

\textsuperscript{11} Corporate Social Responsibility
the problems? You can always pick up the technical skills. ... It is perfectly OK if the next generation cannot derive the Navier Stokes equation. We’ll always see people who will be technically advanced. ... I didn’t learn any critical skills. I could memorize any equation, I could whip through stuff, get really good marks. Was I challenged? No. I wasn’t challenged. Was that the way I should have been taught? Probably not.

Most interviewees were able to see the need for both technical and social competency, and described the tension involved in finding an appropriate balance. The next two quotations suggest that these two segments of engineering must both be present to complement each other.

JDJV: Can we teach engineers to be capable in their social role and to remain technically competent?

Ca4: I don’t think it has to be a diluting of technical knowledge. I think it should be complementary. I don’t think engineers a lot of times think about it at all. Even if they are thinking about it a little bit, that’s a good thing. Like obviously, you don’t want to completely overshadow their technical training with social awareness.

We always say to the university, if you send us engineers with only technical skills, that is really problematic for us. The engineers we see excel here are engineers that are excellent technically, but more important, have skills beyond engineering. They know how their work fits into the scheme of things and they have a sensitivity of the design. It is integral to their thinking. It is those engineers who make strong leaders. We just did a project on a drinking water device that would be affordable to incomes of less than $1000. So we needed to be able to take water from a raw source, from a river, pond, or from a mud
puddle and make it potable. Those that took purely a technical approach made a pretty neat contribution, but those that were able to bring it to a practical and affordable application, they understood the bigger picture and it was really neat to see. (Ca16)

While multidisciplinary work involves one student learning material from a variety of disciplines, interdisciplinary work means students would work together with people with different areas of knowledge. It brings students from different backgrounds to work together and learn about other ways of thinking.

I’m really big on interdisciplinary. Even bringing engineers into contact with social science students. I think there is a big value in that. We’re trained to think differently. I don’t expect to find answers to my problems which I think engineers find really frustrating. ‘What’s the answer?’ ‘Well, I don’t know.’ (Ca4)

The engineer can find some flexibility as he or she seeks the right balance between technical and social details by developing effective communication skills. Good communication allows for many solution options when working in an interdisciplinary team.

The way we solve real practical problems is to have interdisciplinary teams. The only thing that is important is communication — to be able to understand different people and where they are coming from. ... If you are an engineer, you should be able to communicate with an economics, a sociologist, or a politician. I don’t think the engineer should be an all task man (sic) who understands as much economics or as much history as everybody else. I don’t believe that. He won’t be useful for anything. He should be able to communicate effectively across society. (Gh6)
The next quote again captures the importance of working across disciplinary lines and captures more about what it means to be a capable engineer: competency in one’s own discipline, awareness of multiple disciplines, and an ability to communicate and work with other disciplines.

Ca13: I would like to see an education that fosters a respect for what good responsible arts students contribute. Usually, they do provide the motivation for everything [engineers] do. I’ve had to repeatedly tell myself to do my job and pay attention to what those differently trained people are doing for the world around me. So when the development studies student says, this is a problem and this is how it could be solved, I can say, ‘I recognize it is a problem and thanks for bringing it to my attention and I’ll see what I can do on my end of the spectrum.’ ... I think we do need to foster better respect for the arts students and if there is a way we can combine them into some project — ones that are not just lip service and fluffy.

Intrinsic to interdisciplinary work is that everyone ‘recognize their role on the team.’ This needs to be balanced with the strengths and weaknesses of reductionism. The balance between social responsibility and technical competency must be debated and will never satisfy everyone. What seems clear from the data, as the next quotation suggests, is that there is evidence of imbalance:

I think it is difficult [to see how technology exists in a social context] for those of us who live in a society where a lot of professional roles have been specialized. You don’t have to go too far off the urban centre to find people who are farmers, and scholars, and poets all in one, with a lot of different skills. The idea that we would carve off one of those, and that we’d have one person who would only be good at this narrow range of skills. I mean, that is a fairly artificial kind of skill specialization that characterizes advanced capitalistic society,
right? ... It sounds to me like it is about righting a balance. The scales have tipped a little bit too much in one way where we’ve shaved off the technical completely from the social. ‘Do we need it?’ ‘Can we sell it on eBay?’ Well that isn’t the only standard to decide whether or not something is a good idea. (Ca1)

Given the evidence of imbalance, the engineering faculty must adjust to remain relevant.

   I believe that most professions and programs are changing to reflect what the current demands and needs are. And if you continue to study and stick to the same curriculum all these years, you may cease to be relevant as our society grows and develops. So if engineering does not adjust to include more social issues, it will cease to be relevant. (Gh8)

5.2.4 Category 4 - All curriculum should be built around social impact and community needs

In the next category of understanding, humanitarian engineering is seen not only as something to which each student needs to be exposed, but also as something on which all curriculum should be built. Curriculum adjustments should be made in as many engineering courses as possible to include humanitarian engineering concepts, including social impact and human need. This understanding builds on the previous category — it is necessary to properly balance the curriculum while adjusting it in this way.

   The understanding described in this category focuses on the need for complete integration. Some discussion is included here, but later in this thesis, there will be additional discussion with suggestions for the practical means for implementation.

   I think new courses would be beneficial. I think what would be even more beneficial would be to get awareness of these issues integrated into the other
material so that it is something that people are constantly thinking about. And it’s not something only people with a prior interest in social justice or a prior interest in development issues to come to. That way it will at least possibly reach a broader community because otherwise it is preaching to the converted and I think you need to branch out to other people. But getting it integrated into the rest of the curriculum is certainly a bigger challenge, but that is the best way. (Ca4)

One interviewee argued that the social side of engineering, an important aspect of humanitarian engineering, belongs in every course:

I think the social impact is a huge thing. And I think that in every course we teach in engineering, we should try to weave in those concepts. In all of the courses I teach, I try to bring some of that material in. Now whether we need stand alone courses: yeah, maybe we need stand alone courses. (Ca14)

Another interviewee spoke passionately about the need for all of the engineering curriculum to have a focus on social justice:

This definitely has to reach everyone. We need to get into every class and the message needs to be clear and subtle. One course on engineering and social justice is not enough, but sometimes all you really need is one or two professors who are correctly aligned to move the entire program in the right direction. (Ca6)

Several interviewees pointed to the social science and humanities requirements stated by the Canadian Engineering Accreditation Board (CEAB). One interviewee suggested that a more unified approach from within the Engineering Faculty was better:

Ca14: I tell the students that we really should be doing everything we can to reduce emissions. I try to fold it in when I can. But, like I say, in a 50 minute
lecture, it will be a minute here and a minute there. But if that is done in every course where you can fit it in, over 4 years, it can really make an impact. Because when the students take their humanities course, it is not clear to them how they factor in.

JDJV: You’re saying that it is disjointed?

Ca14: It’s disjointed. That’s right. But we have an opportunity to bring things together.

One interviewee discussed the necessary, but often forgotten, relationship between the university and the surrounding community.

All curriculum must be connected to something that is real, and beneficial to society. We must encourage students to apply knowledge to need and this requires a holistic, integrated approach to teaching. (Ca3)

A Ghanaian interviewee expressed a very similar view:

If we want to develop, we need the help of the engineer. As a people, and our cultural practises, we are having serious problems with whatever it is that we are learning at our schools — it is not solving our problems. So, to me, our engineering students should always be finding a way to see how to solve the problems of our communities. We have to solve those problems. That is what we have to do. As we speak here, the students at KNUST\(^\text{12}\) know more about London than they know Kumasi. We are going through the school without really knowing the reason we are going through the school. We forget that we need to solve problems for our people. (Gh13)

In Category 1 of this phenomenon, it was seen that one way of understanding a humanitarian engineering curriculum was that it should be a separate course or program for

\(^{12}\)Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
those who were interested. Further levels of understanding have suggested that humanitarian engineering should be presented to everyone. It is important to point out this higher level of understanding does not rule out a separate course or program.

There will never be enough social impact analysis so we need a program like humanitarian engineering for those who want more. (Ca5)

Another statement made during a televised debate by a consultant, captures this level of understanding well.

It is a real opportunity for universities and colleges and education in general. It is absolutely essential to integrate into the problems that are assigned to students, the social responsibilities and environmental aspects. I think that tacking on a separate environment subject or a separate social responsibility just makes it look like an add on. It has to be integrated into the case studies that are given to students so that they begin to realize early on that these must be integrated.\(^\text{13}\)

An anecdote from one interviewer helps summarize this category. In a village in India outsiders wanted to provide a pump. One outsider, who was in the village for three months, noted that the entire time was spent arguing over where to build the well.

It was a geophysics problem to determine where to build the well. But of course, it wasn’t that problem at all. It was about what neighbourhood the well was to be built in and whose houses were in that neighbourhood and what power it would afford the heads of different families. And there was actually a point where someone was stabbed and wounded quite badly. Everyone agreed that [the well] was the right technology for what they needed, but

\(^\text{13}\)Carole Burnham, Environmental Consultant, Principal, Carole Burnham Consulting on TVO’s The Agenda with Steve Paikin, February 13, 2007.
the larger social and political context was the barrier to having the technology work. Technological intervention always happens in social and political, and even economic context. (Ca1)

This category stresses that technology always exists in a social context and an engineering curriculum needs to reflect that.

5.2.5 Category 5 - Some unlearning is necessary before this curriculum can be effective

In the final category, humanitarian engineering in the curriculum is seen as appropriate, but is only able to achieve its goals of social justice if the students unlearn certain things so that they can place themselves in the same social location as the underprivileged. If this is not done, there is a great risk that the program will be a charity-driven endeavor that will benefit the rich more than the marginalized, perhaps at the expense of the marginalized. This understanding essentially states that if we want engineers to make a positive contribution to local and global society, the engineer must first understand her or his global impact and social location. This suggests that engineers must be taught critical thinking skills — something that is currently absent in the curriculum and is distinct from a mathematical approach to problem solving.

If we want engineers to make a difference in society, engineers must understand their global impacts. Critical skills are important, for better engineers — we must focus on these things. (Ca5)

In addition to teaching students to think and write critically, significant unlearning is necessary.

Humanitarian engineering has to be about undoing the education we’ve had so far. Much of it has been vindicating our role as people in the global
North for our responsibilities in the global South. The most critical thing is for people to understand the root causes and not just a surface appreciation. (Ca2)

First of all, there is a reasonable danger in exposing engineering students to issues of human need and marginalization. It is a common thought that engineers are problem solvers, and while there may be significant emphasis in their curriculum on problem solving, their tools are usually limited to technical solutions. Based on this training, engineers will want to find an appropriate technical solution to some social problems, even when a broader solution is better. The engineer’s tendency to solve a problem with a technical solution must be counter-acted with the knowledge that the best solution to a problem may not have anything to do with technology.

JDJV: Should discussion on human development and poverty reduction be included in the engineering curriculum?

Ca4: I think it should be included. Yes. But it is a slippery slope to say that technology is a solution to all of their problems and I feel like that may be the way some engineers would maybe take that. So I feel like that would need to be addressed: where technology fits into the broader picture of development.

How much culture, politics, economics, society stuff can we pack into an already packed curriculum? Very little. What we can do is create an appreciation of the complication of the world and undoing this attitude that engineers can solve it on their own. (Ca2)

The perception that someone who is very good at math and science will automatically make a good engineer also needs to be examined. This attitude diminishes the creative side of engineering. Often students who are good at math and science are encouraged to go into engineering, thus perpetuating the belief that engineering is about the math and science alone.
Another area of unlearning is related to the first: an engineering student must resist the desire to specialize without first seeking tools for communication and broadening thought. Robert Chambers argues that current university education is “a narrowing, a focusing of attention and a refining of skills which exclude in order to specialize. Disciplinary academics and practising professionals meet, listen to and argue with those of similar backgrounds” [55]. But engineering schools conform with Chamber’s analysis. They continue to encourage specialization because the specialist has power when he or she has something that others lack.

The desire for specialization comes at the expense of holistic approaches to problem solving. In terms of development work, holistic approaches are necessary and will only be applied by a student who unlearns this set of perceptions.

What is technical rigour? So, if you are learning to design with appropriate technology, in a development scenario — is that too soft? Some people think that you get too wishy washy with the technology with this. Well, I don’t think so. A design process doesn’t just include math, it includes thinking about the consequences of what you’ve done. It includes inclusively. Include the whole picture for your design, don’t just include the numbers. (Ca5)

A third area of unlearning is connected to ambition and humility. The following quotation successfully captures this idea:

I think that if Queen’s were to educate engineers with a more refined common sense, maybe the kind of common sense that was so proudly reminiscent of the greatest generation where I think they would say, ‘You’re fooling around with your high tech toys, just save a little energy and you’ll have a much better impact.’

It’s tough because we try to get our students excited about technology, they
are after all, engineers. But we forget that some of the very best engineering contributions are the simplest solutions.

The most socially responsible engineers will be the ones who get the least glory. They’ll be the ones who have that refined common sense who are content without making a splash, who are content just to be good people. That is a very difficult thing to educate anyone to be because almost anyone who goes to university goes for reasons of ambition. (Ca13)

The most challenging unlearning involves an understanding of the dominant ideology that surrounds our corporate, economic, and political interactions. In this final understanding of humanitarian engineering, it is seen that the dominant neo-liberal ideology creates wealth for a small number, but it is damaging the livelihoods of many.

The engineers are the soldiers of industry. We are soldier/mercenaries. As long as the the captains of industry keep us marching in the directions we are, we can’t help but find ourselves drawn in that direction. I feel it. I want to make good money. But most of it is the people who have absolutely no conscience. So stimulating leadership out of engineering is one of the solutions.

I think that if people pursued engineering as people who wanted to live simply, then that is the kind of values that we need to stimulate. (Ca10)

Earlier in the same interview, the interviewee had some other things to say about the status quo:

JDJV: Do you think that we should be teaching engineers about their social impact?
Ca10: Yeah, I just don’t know if you can. Right? That’s the conclusion that I’ve come to. ... I don’t know how you change someone. A lot of these kids
come from suburban settings with complete isolation and they come here so that they can stay that way.

JDJV: So, do you think that teaching something like humanitarian engineering is impossible at an institution like Queen’s?

Ca10: Well, the definition of engineering that we were taught is that it is the art of applying science and technology to better the human condition, which in my mind is humanitarianism. So engineering should be inherently humanitarian. So the question is, is our society inherently humanitarian? And it is quite clear that it isn’t and as long as we keep going the way we are going, we will just keep serving their interests. So engineering is not a profession where we should remain impartial. ... We’re all going to look for the best problem available to us and those are ones with the most funding available and those ones are going to be the ones backed by those in control and the people in control are happy with the status quo.

Enabling this unlearning is a profound challenge for the engineering curriculum, especially since a certain amount of ‘in-the-box thinking’ is required to get into engineering and because engineering programs are administered by people who have succeeded within the current structure.\textsuperscript{14}

The hierarchy for this phenomenon, listed in Table 5.2, is important for this thesis for a number of reasons. It can be used to help determine whether or not humanitarian engineering should be implemented, and it can point to some practical ways in which that can happen, if desired. It also indicates a wide variation of opinion on exactly how to implement humanitarian engineering and points to the difficult task of finding a balance between social and technical content in the curriculum. These findings are significant of

\textsuperscript{14}Italian diplomat, artist, and philosopher, Machiavelli wrote the following in 1513: “It must be remembered that there is nothing more difficult to plan, more doubtful of success, nor more dangerous to manage than the creation of a new system. For the initiator has the enmity of all who would profit by the preservation of the old institutions and merely lukewarm defenders of those who would gain by the new ones” [188].
course, because they are directly related to the research questions posed in Chapter 1.

5.3 An international humanitarian engineering placement

Typically, the next topic covered in the interviews flowed out of the conversation on the engineering curriculum. After talking about curriculum changes, a natural progression was to talk about the proposal of offering an international humanitarian engineering placement for academic credit. The aim of this third part of the study is to identify and describe the qualitatively different ways in which the interviewees conceptualize an international engineering placement. The specific goal was to collect a pool of understanding of the concept as wide and various as possible. Six categories were found in the data and are shown in Table 5.3.

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<thead>
<tr>
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<th>Placement is inherently good</th>
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<td>2</td>
<td>Placement requires careful training</td>
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<td>3</td>
<td>There is a lot of potential for harm, but placement can work with right approach</td>
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<tr>
<td>4</td>
<td>Placement is most valuable for student learning</td>
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<td>5</td>
<td>The learning experience comes at a great cost</td>
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<tr>
<td>6</td>
<td>Placement must be about social justice</td>
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Table 5.3: The outcome space for the third phenomenon: An international, humanitarian engineering placement

The amount of time spent discussing this phenomenon was second only to the previous one. The conversation often came back to the placement several times, indicating, perhaps, that people tend to think of an international placement when they think of humanitarian engineering. An international engineering placement was a favourite topic of discussion during conversations and interviews in Ghana.

I have chosen to focus this section on international placements. When I started talking about placements in a marginalized community, most people immediately assumed I wanted to talk about international placements. Local placements should be considered
with equal vigour, but will not be discussed until the next section. In addition, many inter-
viewees were quick to point out the engineering needs of First Nation Canadians. Even
though such placements would not be international, there are many similarities between
working in a First Nations community and an international placement. Thus, the discus-
sions in this section is applicable to placements with Canadian Aboriginal communities.

5.3.1 Category 1 - Placement is inherently good

In the first category, an educational international placement is seen to be intrinsically good.
Interviewees were quick to point out numerous benefits. Several interviewees suggested
that the international placement was a requirement for a successful Humanitarian Engi-
neering program. I asked one interviewee if there should be international placements and
he replied,

I almost assumed that it would have that element because without it, it
would be hollow. (Ca11)

Other people were equally enthusiastic about the idea of the placement.

These projects are life changing. [The students] come back with a whole
different approach to life. ... They are incredibly beneficial for our students.
(Ca16)

It’s a great idea. That’s how you open people’s eyes. You get students that
have never been exposed to poverty. They’ve lived in the suburbs. They got
their parents’ car when they were 16 or 19 or whatever. Many of them have
their own car. They might have had their own job at a restaurant or something,
but never really worked hard and you put them in a situation where they have
to actually see and interact with the poor or people with disabilities. It really
makes them think. Much more than showing them films. It makes it real for them. (Ca17)

Opportunities to interact with marginalized or impoverished people is seen to be extremely beneficial. The following quote suggests that there can be benefit through helping a community alleviate a problem and that there is an opportunity to learn because of the cross-cultural experience. In the end, the overseas endeavour is described as very positive.

JDJV: Is there a benefit for us to be sending engineering students to developing countries?

Ca7: I think most certainly, yes. For obvious reasons for the country — if their water is polluted and they need clean drinking water and they’re not sure how to do it. There’s a benefit to them and we’re loving our neighbours by going over there and helping them do it.

There’s also great benefit for the student in going over and working in another country. For one thing, it is going to humble them and they’ll realize how fortunate we are in Canada. We don’t have to worry about drinking dirty water and having to walk miles for it. So just that experience alone is a very valuable lesson. ... Maybe they’ll learn about how to treat their elders or how to live in community. It might not have anything to do with why they went over there. They might have gone over to install fresh water pumps, but they come back with an idea of how the elderly can watch the children or how something else is done.

Similar ideas are portrayed in the next quote. It also suggests that international placements are good for the appeal of the academic program.

First of all [international placements] attracts people to the program. You can read about this all you want, but there is a difference to see how people actually live their lives. (Ca4)
Another interviewee suggested that a humanitarian engineering program could provide skills necessary for the work world:  

JDJV: How has engineering and development work that you’ve done helped with your career? Has it made you a better engineer?

Ca8: I think that it definitely helped me. It hasn’t really changed how I run through my calculations and do that sort of stuff, but I think it has helped me get in front of a crowd. It is really great immersion. The other thing that is really neat too: before this all of my experience was in school and in school you are learning, but as soon as you go into a developing country you are an expert or people consider you an expert and people care about what you have to say. There is a bit of a transition in your mindset where people are listening to you so you better give a good answer. You can just as easily spread misinformation as good information. I think that in consulting that is also another good little thing to remember in your everyday work. We are often looked at for answers to things.

In thinking more broadly, several people suggested that humanitarian engineering placements would have monumental impact. They would increase the quality of engineering designs and simultaneously create a critical mass of thoughtful workers. One interviewee said that this type of opportunity was necessary for the students to fit into the current globalized way of life. The following quote came very early in an interview, immediately after a discussion about humanitarian engineering in general; an international placement was automatically associated with humanitarian engineering.

\[15\] A related note: co-CEO of Engineers without Borders (Canada), George Roter, says that the students that EWB sends to various places in the world for placements are in high demand upon their return because of these additional skills. He also quotes Patrick Pichette, President of Operations at Bell Canada in saying that EWB’s overseas program is “a unique training ground for Canada’s future leaders.” [189].
Ca15: [Engineers who travel overseas] will be more relevant in our globalized society.

JDJV: Why would they be more relevant?

Ca15: Because they are going into different cultures. They are going into different contexts. And if they are not, they are going to be failures. They may be the best engineers, but if they do not fit and work with other people, there is going to be a problem.

JDJV: So, you are saying that, inevitably, students are going to have to work in different cultures.

Ca15: Definitely. They need to get that international experience. ... They will see another way of doing the same thing. And I think that will only enrich our students.

Another argument that an international experience for a student is good for the world, as a whole follows.

If the university can afford to, it is a good idea. I can see from people who have been to developing countries and have met people from different parts of the world, they care more about those countries, which is a good thing for the world. (Ca9)

Many of my discussions in Ghana also demonstrated this category of understanding. Many of the Ghanaian interviewees saw the placement as inherently good. One interviewee immediately said that the placement was a great idea and added that:

Engineers can help bring more modern technology. Africa requires this. ... Africa needs technology for development. (Gh15)

Another interviewee had similar enthusiasm, but looked at the benefits more from a community level.
I think it is very good. Especially in our situation. When students go outside and practice their theory in a more practical setting, I think the communities will benefit from their services. And the engineer will learn from the community about their practical needs and it could set an agenda for some practical research. ... So, once you are in the community, you will find such interesting needs which trigger engineering solutions. (Gh7)

In summary, an international placement was seen in this category as a great advantage.

1. It will create an opportunity to help a needy community in a low income country.

2. It will provide learning experiences which broaden students’ perspectives.

3. It is seen to prepare engineering graduates to work in a global world by creating awareness of global issues through giving experience in cross-cultural communication and international team work.

4. The humanitarian engineering placement is seen as a great way to develop leadership skills in engineering students, while helping people and communities in need.

5. Finally, a humanitarian engineering placement will attract students to the engineering program — a benefit to the faculty and university.

No contrary opinion was expressed during the formal interviews, but in several informal discussions, the humanitarian engineering placement was seen as an inherently bad idea. One person asked, ‘Why should our tax dollars leave the country?’ This attitude was rare.

5.3.2 Category 2 - Placement requires careful training

In the next category, the placement is seen as favourable only if careful training is provided. There are many administrative, logistical, and safety issues involved. Epprect says
that “the possibilities for worrying about young, relatively privileged, often naive, linguistically underdeveloped, and sexually curious students sent from North America to work for a short stint in the developing world are, in short, truly endless [156].” This category examines concerns from the sending country and institution’s point of view.

I definitely see the benefits and challenges, of course — not huge challenges, operational challenges. (Ca11)

The placement can be good, but we have to make sure the students are properly prepared. Communication and safety issues will have to be well thought out. (Ca5)

If we don’t properly prepare the students, it will not work. We don’t want to send them and have them turn around and come home because they were not prepared. (Ca15)

Other interviewees brought up the critical issue of liability when the idea of humanitarian engineering was initially suggested to them:

You will have to be very cautious on things like liability. For a university sponsored program, you don’t want anyone who is going to be attacked. Or sending someone near a conflict or in an area where they could create conflict through being seen as political disrupters, trying to change the status quo. You have to be pretty cautious. ... I know some groups just won’t send their people into certain places because it is way too dangerous. The students could be just one more target. (Ca17)

I’m concerned about liability. I have no idea what the [university’s] lawyers would say about it. If we send a student off to a place and they get killed, I would think that that would get very ugly. You’ve got to be careful with what
those engineers get involved with. ... We have to be sure, if they go somewhere, that they are trained and prepared for whatever they are going to see. That’s not a trivial thing. (Ca14)

An interviewee in Ghana described a very difficult situation where an intern died during her international placement. He also suggested that logistics are the most difficult obstacle.

Gh6: I like the idea of an exchange experience. It is just the logistics that are difficult. We had an exchange program with a university in North Carolina and we had a girl who was staying at Steven Paris Hostel\textsuperscript{16} who died.

JDJV: How did she die?

Gh6: From something. Some complicated malaria or something. It was a very big nightmare.

This second category portrays a humanitarian engineering international placement as a good idea if safety and other logistics are well considered. International travel can often put a student at risk — overcoming these risks is critical to a successful placement.\textsuperscript{17}

5.3.3 Category 3 - There is a lot of potential for harm, but placement can work with the right approach

The third category of this concept adds to the previous one, except that the concerns are not just for the sending institution, but also for the receiving community. There are concerns over the impact of the placement, but the over-riding perception in this category is that the placement can be beneficial with the right approach. People going overseas without the right qualifications increase the risk of failure. Harm, to some extent, is inevitable, but

\textsuperscript{16}This hostel is on the campus of Kwame Nkrumah University of Science and Technology.

\textsuperscript{17}Worth the Risk by Myles and Mitchell comments on the increasing trends for Canadian students to work overseas despite the dearth of resources and guidelines to ensure safety. It could suffice as an important resource [190].
with the right approach much good can be done. The following two short quotes introduce (and summarize) this category well.

Problems could arise if a bad person is sent. (Gh1)

Depending on your outlook, you can have a real positive experience overseas, both for yourself and the other country. (Ca8)

One interviewee suggested that the potential for harm can be reduced with the right degree of openness from, and support for the student.

I think that there is definite potential to be a nuisance. I think that it depends on the person anyways. It’s going to depend on the student and I think that it is going to depend on how open the student is for learning from other people. ... I think that in general, it will probably be good, but there has to be some sort of supervision and quality control. (Ca8)

A student’s openness was emphasized as a key component to the success of an international placement. For example, after a discussion about some of the concerns of the placement, one interviewee stressed the importance of attitude and humility. He said that visitors cannot think they know what is best for another culture:

We should go with an open minded approach. We should ask them how can we help you. ‘We hear that you’re having trouble here.’ If they are — if they aren’t we don’t really need to go and help them. If they are, we should first ask, ‘What can we do for you.’ We shouldn’t say, ‘This is what you need. I have your solution.’ You should sit down with the elders, or the council and say, ‘Here is what we have, what can we do for you?’ It’s just a much friendlier way. And they might smile and say, ‘They’re not being arrogant, and rushing, and telling us what to do.’ ... The way you approach a discussion can really turn them on or off. (Ca7)
This next quote expands this thought:

I think [the success of a placement] really has to do with the sensitivity of all of the people involved: the senders, the receivers, and the people being sent. It really has to do with their sensitivity about positionality, about paternalism, about colonialism, about the whole constellation of things that have to do with power between people — people of different cultures, people of different genders, people working with different generational separations, people with different educational backgrounds, dominant culture, minority cultures, all of these sorts of things. (Ca1)

While understanding the engineering/development placement as a useful endeavor if the correct approach is taken, several interviewees focused on the need to remain community-centred. This of course, is related to the student’s attitude, but it does go beyond that. It is not just about asking the community leaders about their needs, but it is about working to know and understand some of the dynamics of the community.

This point was stressed in some of the Ghanaian discussions. Many interviews and conversations in Ghana around the placement involved stories of failed development projects where the development agents did not understand the local culture. At the same time, there were a couple of positive stories that involved foreigners who spent the time to really understand the nuances of the community. One interviewee told a story about how an outsider really endeared himself to the community because the outsider was eager to learn the language, eat the food, and get dirty by working hard and breaking through some social barriers. She gave the following advice.

Let the people feel like you are part of them. It’s the way you talk to them.
It’s the way you make them feel. (Gh2)

The importance of the relationship between the student and the community cannot be over-emphasized. The following quote suggests that this relationship along with a strong
learning attitude can help optimize the placement.

Placements can be powerful, not just for the placementee, when there is real communication, real relationship, over what’s needed. Usually, the intern is told by his [supervisor] what you’re going to do and arriving at the placement, finding out that that isn’t what’s really needed at all. Or, they already have people here who can do that. In real community, the student can have enough self confidence, but also humility to say, ‘what can I credibly do?’ ... ‘I’m going to do something else. I’m going to ask people about how I can fit in.’ And so they can empower themselves to revamp their placement in response to what they were able to learn from the locals. (Ca1)

The next quotation echoes the previous suggestions for the right approach, but also points to the need for very careful planning and carefully choosing a placement partner.

JDJV: So if I were to stop you now and hand you a ballot and ask you to vote ‘yes’ or ‘no’ to the placement. Would you be able to do that?

Ca4: I would say (pause) yes. [The program that I am in] has a placement program. First of all it attracts people to the program. You can read about this all you want, but there is a difference to see how people actually live their lives and it can be done in a way where it is not detrimental, but it has to be very carefully planned. And I think it has a lot to do with the individual student too — in terms of how they view their relationship with the community.

Another extension of this idea: the right approach also means the appropriate length of time for a placement. If the right strategy requires immersion into a community, the experience should not be too short. A four month placement fits conveniently into most university’s trimester calendar, but perhaps is not long enough. Some people see no problem with a four month placement, but it is clear that “parachuting in and flying out” is
problematic; people are concerned with making relationships and then immediately walk-
ing away from them. This will be discussed in more detail in Section 6.6: Implementation.

A final thought on this category of understanding the international engineering and
development placement as a good thing if the right approach is used, comes from Parker
Mitchell, a co-CEO of Engineers without Borders (Canada).\textsuperscript{18} On the issue of doing in-
ternational development work, he says, “My advice to you is to get out in the field and
understand the field” [191]. This category is concerned with a healthy understanding,
attitude, openness, and approach.

5.3.4 Category 4 - The placement is most valuable for student learning

In the fourth category, the international humanitarian engineering placement is seen as
something that offers only a small chance to really improve community directly, if any-
thing at all, but it is valuable for student learning and awareness. The international ex-
perience offers the students many lessons: communication, language, culture, compro-
mise, and to fend for themselves, for example; the students will return with great personal
growth. There is no surprise that students with this sort of experience are valued in the
work force. In addition, the returning students are a valuable asset to their sending agency.

JDJV: Is there merit in an international placement?

Ca13: There might be. Hard to say. Hard to quantify. When you send
someone overseas, they probably can’t help come back with something from
the experience.

They learn to appreciate what works there and what doesn’t work there
because they work with all the nationals there and those people provide a great
deal of leadership. The learning they do is a great deal more than the teaching
they can do for the nationals. (Ca16)

\textsuperscript{18} At a talk at the State of the Planet, 2006 Conference at the Earth Institute, University of Columbia.
Opportunities already exist for engineering students at Queen’s and elsewhere in Canada to get involved in engineering and development projects during their summer months. One interviewee from another university talked about the positive and negative impact of placements from her university on the student, the NGO, the host community, the host family, and the sending institution. She suggested that the placement did indeed create some problems, especially because of the short time frame, but the learning opportunities for the student and the sending institution were great.

JDJV: Is it good that you are sending students overseas?

Ca3: It is something that is important and has benefits. The real benefit is when the student comes back. At [our university], the students have to present to the major sponsors, the Rotary, the first year engineering students. ... It comes down to their experience and their ability to allow others to feel the same thing that they felt, while overseas. That’s where the value is, I would say. (pause) That’s really important and that is to be counter balanced against their effect overseas — whether they are creating some sort of cultural dependency. And they are only there for 3 and a half months. They are not there long enough to really build trust and create relationships and partnerships that are so important. You sort of just get started and then have to go back to school.

It is ironic that the person who has the cross-cultural experience, with the intent of helping, will benefit the most, while it is questionable whether the experience will be a benefit or a detriment to the host.

An international placement is going to benefit the student the most. You can read about cross-cultural experiences, but experiencing it is key. It is a trade off between immense benefit to student and potential danger to community. (Ca4)

See the discussion in Chapter 3 for more information on the Queen’s Project for International Development (QPID) and other organizations.
A placement is really rich for the intern, but is that the point? (Ca1)

One interviewee discussed how life-changing an international engineering project was for him. After lots of talk about the danger of the project, he said,

I owe everything that I think now of the world — all of the motivation I have to this event in my life. If I hadn’t had it, I wouldn’t think this way right now. But I recognize how dangerous of a process it was. (Ca2)

Later, after talking about the risks, I asked this same interviewee if the great learning experience was worth the expense. He said,

Because we are not an international development agency — as a university, we’re an education institution, it is from our point of view, worth it. The educational worth of sending students abroad is infinite. (Ca2)

Similarly, the following dialogue repeatedly stresses the benefit of the learning. The interviewee suggests that it is important to be explicit about the student’s experience being mostly about their own learning. It is ironic to note that the student can contribute the most to the host community when he or she goes with the attitude of ‘going to learn.’ This dialogue is useful also because it connects with thoughts from Category 1 (Intrinsically good) and Category 3 (Requires right attitude or approach).

Ca15: When you send a student overseas on a placement, it’s not just an academic credit that he or she gets. She learns far more than that. She learns ... to travel. After getting there, they circumvent the politics of working there, getting to know people, how do we work with people, how do we get our work done? All she learns is through the process and no one has taught him or her how to do it. But he or she will learn that and I think that is what makes a placement worth it.
JDJV: You have focused a lot on the learning of the student, yet so much of this is done in the name of helping, right? The students want to help and yet you have focused on the student learning. Is there a problem here? First of all, is the student able to help?

Ca15: You see, if anyone who works in an aid program, if he or she thinks they can contribute a lot to others, yes, she will contribute. She will help. But actually what he or she learns is far more than he or she can contribute. We may take the money with us, yes. We may have some expertise, yes. But actually, in the learning part, the person who goes gets far more than the other person gets. So I think it is better to acknowledge that at the very beginning and say to the person, yes, I have come to help, but I have come to learn too. So that that person, that country person or the placement person, knows that this person has two reasons for coming here — one to contribute and one to learn. So, I think it is necessary for one to admit this at the beginning. Many people don’t.

While the point of this subsection was to show that the main benefit of the international placements was the students’ learning opportunity, several of the quotes also alluded to the large dangers that could be associated with international placements. In some of these quotes the interviewee discussed a trade off between the learning opportunities and the potential problems. The next category discusses some of the risks in more detail. The following quote again discusses the great learning benefit to the intern and mentions the trade off, and in doing so, points to the next category.

I think that it is obviously for the benefit of the student and not the benefit of the community. I think there is an enormous benefit to the student for going over and an enormous amount of awareness and a deeper understanding that comes from doing that kind of a placement. But there is obviously a danger in using a community as a learning tool. Do you know what I mean? There’s
a horrible power relationship in that. I mean, what are you really going to do in four months. Not a whole lot. ... It is very much a balance in how much you can justify the educational opportunity with the detrimental impact on the community. (Ca4)

5.3.5 Category 5 - The learning experience comes at a great cost and the right decision might not involve a placement

In this next category, the international humanitarian engineering placement is seen as something that comes at a great cost. Cost was acknowledged in the previous category, but it was assumed that the cost was smaller than or equal to the learning benefit. This category suggests that the cost outweighs the benefits.

The complexity of this issue made it difficult for many people to suggest outright that the placement was a complete mistake, but the interviewees who showed this level of understanding could readily point out the great cost. Essentially, this category contains two groups of understanding: one that could identify the many potential problems and one that saw these potential problems as an insurmountable obstacle.

Several of the quotes in the previous categories have alluded to some of the problems of the placement: creation of dependency and power relationships, for example. The following series of quotes indicate more of the perceived potential problems. First of all, several students indicated that they did not have the necessary skills to work in an engineering and development project and were concerned that they could not do anything useful for an outside community.

I have no transferable skills that are useful to these people. What am I doing here. What kind of a pain in the butt am I. Thank goodness, I can buy groceries, so I’m not just a leech. But really, what do I have that is transferable? I have US currency, right? Basically, that is my transferable skill. It was that I’ve lived
in such affluence that I’ve saved enough money that I can buy groceries for my
host family for 6 months without working. (Ca1)

Several undergraduate engineering students expressed the same opinions. As undergraduates, they have little practical experience, and wonder if they are even capable of
good engineering. A Ghanaian interviewee talked about a problematic intern whom he
had to work with. He was expecting someone with more practical skills, and the partnership did not really work out. He told me,

If I don’t have someone on my back, I can deliver. If you send someone,
send someone who will be of benefit and not an interference. (Gh15)

Many respondents discussed what is sometimes known as the ‘ethics of whiteness.’
This is an assumption that the white outsider, often with flashy technological devices,
knows what is best for an international community. Sometimes this idea is held by the
white visitor, sometimes held by the local people. The white person represents a land
of knowledge, progress, and technology and, as a result, demands a certain amount of
respect and power. The following two quotes capture some of these extremely challenging
and troubling nuances.

I think that a lot of us are still in this white man’s burden mindset where we
think we have some superior awareness of what needs to be done. I think we
over do it and I think that the people who go overseas are aware that we over
do it. (Ca13)

Frankly, I think there are a lot of harmful things being done. I am some-
what skeptical of many NGOs. (pause) Although some NGOs are doing good.
(pause) There is a wonderful little book called ‘Hope for Africa’ by Dr. George
Kinoti, a professor emeritus from the University of Nairobi. He says, ‘I wake
up in the morning and wish everyone would go home — go back to Europe and North America and leave us alone.’ We’re creating a dependence. It’s been very detrimental. It becomes this demotivational force and it gives people an inferiority complex. (Ca16)

The following excerpt refers to the same phenomenon and points to the danger of reinforced stereotypes. Prior to this excerpt, the Ghanaian interviewee had discussed many benefits for the Canadian engineering students in Ghana.

JDJV: There’s no doubt that it will be great for the student, but will it benefit the community in which they will work? Is this just one more thing that the West is taking out of Africa: an exciting experience?

Gh9: That is an interesting way of looking at it. For so long as it doesn’t contribute to an improvement in the living condition of the developing country people, the Africans, then I guess, yes. But if it does contribute to improvement in the living conditions, then I say it is worth it. Even if it is something that the West is taking out of Africa, if it is contributing to an improvement in life, then it is worth it. Now, this isn’t going to be the first time there is placements, so do international placements contribute to life in the developing world, that’s a big question. That’s a big question.

I can well imagine that there are communities that can have their, (what’s the word), their colonial mentality reinforced with the coming of interns. I talked about these EWB guys. They came and they did so much work. It is possible that the people think that these white guys are so much better than our black guys who don’t do anything and they reinforce stereotypes and so on.

In another interview, we discussed the introduction of a rice dehuller into a rural African community. The interviewee suggested that the stated goal of the project was

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to alleviate manual labour and liberate the women. She wondered why the goals were
to change the family structure and why outsiders should be trying to give women more
power. Are these ideas coming out of Western feminist thought or was it what the women
wanted? She said:

Even if the technology is doing what it is supposed to be doing and achieving impact, the disruption in the social system might outweigh benefits of the technology. And it is almost inevitable when implementing technology, especially if it is dramatically different than anything that they have used before. (Ca4)

Several people who had been involved with international development projects stressed how students add extra work load to the local environment because of accommodations, transportation, and translation, for example. Often this local environment is already stretched to its limit.

Someone who is new to any environment is a huge burden. Right? They don’t know anything, maybe they don’t speak the language very well, they are kind of like a child — they have a lot of needs and are not actually contributing much back, at least in the short term. We have to take seriously how much input the local community has to put into that person just to get them up to speed. (Ca1)

Other problems included the expense and the ecological footprint of this sort of endeavor.

If we are going to be humanitarians and be responsible individuals, then we can’t go flying all over the world for our education. (Ca10)

Trafficking students all over the globe easily lends itself to hypocrisy. (Ca13)
The expense should be a real concern. Absolutely. And how much carbon emissions are you emitting. And where is that money coming from? Why do you have $2000 to get a [plane] ticket to Africa? Because your dad works for a mining company that is exploiting people in Africa. I don’t know. It’s a big issue. Unfortunately, it is not as if that money is either going to go for my trip or that it would go to farmers in Latin America. That’s not a realistic choice. It’s usually, I’m going to go to Ghana or buy a new TV. I’m not saying that’s right — it’s the reality of it. (Ca4)

Another interviewee saw the border-crossing component of the international placement to be intrusive, exploitive, and patronizing.

Ca2: I recognize now how dangerous my experience in Bolivia was for others. The impacts that my presence and project must have had on other people’s lives are not by any means positive. ... I recognize how dangerous of a process it was — not for myself, although sometimes it was — but more for the community I sought to help.

JDJV: And how was it dangerous?

Ca2: How was it dangerous? This is a very big debate, but it reinforces the idea of neo-colonialism. This dependency on outside sources, this destruction of local self sufficiency by the presence of outsiders who are there to help, but most often do nothing. Most often the projects fail. Beyond that we have the impact of arriving, showing a way of life that is glorified across the world, and then leaving and going back to our comfortable lives. I don’t know — to me I put myself in the shoes of the people I was surrounded by there, and I’m afraid that my presence wasn’t a positive one. I didn’t leave anything worthwhile really, but I did show them the wealth and prosperity that I live with and how I was somewhat separate from them and that I came with an intention to
help them and really I was a salesman of the Western way of life. My presence destroyed a whole local philosophy, a whole culture, a whole way of life that prevents them from really really raising themselves and that is what fundamentally needs to happen. Now if we send hundreds of thousands of students across the world it will become tourism — poverty tourism. I hope this doesn’t happen.

In the previous quote, the interviewee made reference to a well known quote from Ivan Illich’s address to the Conference on InterAmerican Student Projects (CIASP): “You cannot help being ultimately vacationing salesmen for the middle-class [North] American way of life, since that is the only life you know” [61]. In this speech, Illich talks about the dangers of paternalism inherent in any international service mission and essentially recommends against going overseas to ‘help.’

Despite all of the criticisms and warnings raised in the interviews, very few were able to say outright that placements should not be part of the curriculum. One interviewee, for example, said that “unfortunately I’ve read very few development projects that have been successful,” but when asked for a final answer, said ‘yes’ after a bit of a pause, quoting student experience and benefits to the sending organization. This quote also captures this tension:

I’m a hypocrite when I say this because I’ve benefited from it, but I don’t want there to be placements. ... I think people are going to be doing it no matter what, so if we can train people to be cognizant of all of these challenges and be sensitive and aware and conscientious when they go, we can minimize these negative impacts. (Ca2)

Most of the criticisms mentioned above have to do with the dangers of intervention in another culture. Technology itself is a cultural entity, and when it is transferred to another
culture, the receiving community must adjust itself to adapt to the technology. Technology transfer is not a straight-forward task and it often has a political dimension. Indigenous knowledge is lost when confronted by imported technology, which in itself may not be negative. But when a new technology creates a dependency, while destroying indigenous knowledge, the transfer is indeed negative. While technology can be used to meet basic needs, transporting technology across a border can undermine a society’s ability to care for itself.

While in Ghana, I heard many stories of failed development projects. In one instance, volunteers from an American university were used to build a small runway. The project was criticized because it cost a great deal of money for a short international stint, and could have easily employed local labour in a community where the unemployment rate is high. Other anecdotes included stories of latrines not used because of a cultural convention unknown to the visiting engineers, or wells that were not used because of lack of simple maintenance. One outsider interested in a development project told me shortly after her first visit to a site, that she did not know what her role should be. “Life seems to be working for them,” she said. Another development worker expressed frustration at the futility of actually reaching the people who were in need:

The people who don’t really need the improvement are getting it. (Ca8)

The final quote of this category acts as a good summary of the fifth way of understanding international humanitarian engineering placements: there are risks great enough to discourage many placements.

The assumption of ‘doing good’ cleans out the ethical problems associated with what we are doing. Of course, ‘doing good’ is actually part of reproducing every sort of paternalistic relationship, right. Like the idea that I could do good for somebody else immediately suggests that I know what good is for them and
that they don’t have any agency of their own or that their agency is somehow compromised. (Ca1)

5.3.6 Category 6 - Placement must be about social justice

In the final category of this phenomenon, the humanitarian engineering international placement is seen as a benefit only if it is about social justice. In spite of the negative impacts mentioned in the previous category, it is impossible to rule out international placements completely, for a number of reasons that will be discussed below.

This category adds to the previous categories: there is a great learning opportunity that often comes with some costs. Whether or not the scales are tipped in favour of international placements for academic credit will depend mostly on the underlying principles behind the individual placements. Thus, it is difficult to either approve or condemn the placement outright because the impact depends on many complex issues, including the historical and cultural context. A couple of interviewees said exactly that:

The answer can never be placements are automatically a good idea or automatically a bad idea. (Ca1)

Practical experience can be a very good thing and so the placement in itself is neither good nor bad. If the student is doing a placement for IBM and learns about how to be dominating and exploitive, then it is not a good placement, but it could be very positive if students could work for alternative communities. (Ca6)

Centuries of damage, including colonialization, slavery, and poorly prepared decolonialization, have caused a plethora of problems including economic dependency and the loss of indigenous knowledge. Short term projects can do very little, but “small things
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with great love”\(^{20}\) can make some important changes in peoples’ lives. The placement can inspire a lifetime commitment to create good change. On the other hand, there is important social justice work to do without ever crossing borders.

The foreigner has arrived from overseas to exploit resources or to spread ideologies. The debate over having international placements or not having them is also complicated by the fact that opportunistic foreign investors are going to remain at their international posts. History cannot be rewritten, and the forces of globalization cannot be reversed. We have already introduced much from the Western culture to marginalized international communities. Whether or not it is the right technology, it is clear that technology from the West is desired, even as indigenous knowledge is being lost. How do these facts affect the argument for and against intervention? Several interviewees reflected on this:

Where I was [on a placement] it was very poor and everyone had a cell phone. And most families had DVD players and their kids had no shoes. And they really wanted their DVD players. It was hard for me to say you don’t need a DVD player, you need clean water. I guess it is a balance because we have gone overseas and now, can we really stop? (Ca4)

Do we have the luxury of doing nothing after all of the damage done by outsiders? Indigenous knowledge has been lost. It is hard to abandon people and this is a difficult challenge, but in many cases you find that people don’t want your ‘help’ anyways. ... Ideally, our focus should be on social justice, which often needs to be anti-government, anti-corporation, and often even anti-NGO. (Ca6)

Short term projects do go beyond the short stay in the developing community. For a student with a desire for social justice, a placement can be the catalyst for a life time of

\(^{20}\)This phrase comes from a quote from Mother Theresa: ‘In this life we cannot do great things. We can only do small things with great love.’
change. The following dialogue captures this idea.

Ca11: It is a minimal effect during their stay. It is an investment in the future. In order for them to be helpful for the community, they need to understand the community and experience what it is like. Let’s bring back that ‘s’ word. They would do some service, but the purpose of the service wouldn’t be so much helping the community so much as experience and it could be illustrated similar to how many engineering companies want their low level engineers to spend time on the shop floor.

JDJV: And the purpose again would be so that the student would then go back and work in that community or in another community later on?

Ca11: Yes. Or that they would practise engineering with a new awareness. And also establish some links and that sort of thing.

JDJV: And do you think that this sort of approach deals with root causes? Is it part of the right move towards justice and equality?

Ca11: I would say it opens the right doors through which we can, whether or not we later utilize that channel is the question. But let’s say it is 1 in 5 who follow up properly there is a benefit, because that 1 in 5 will be more effective than 10 well minded specialists who don’t have a real grasp of the partnering community.

In a sense, many marginalized communities are caught between two worlds. There is a saying in First Nation Canadian communities, that they ‘have each foot in a different canoe.’ One canoe represents the ways of the globalized world, and the other canoe represents a more traditional culture. One interviewee who was from a low income country struggled with this concept. He said, ‘culture is what makes the world a beautiful place’ and then later said ‘you can’t expect people to keep all of their old values — those things have to change with the changing world’ (Ca9). As a society, if we decide we do have a
role, we then have to decide how to best bring these marginalized communities around us from where they are now to a place where they can be more\textsuperscript{21} independent communities. The path from our present position to this more equitable and sustainable position will not be without suffering, though, as dependencies have already been created.

There is a body of literature that suggests that the removal of unfair trade rules is much more useful than aid and development projects.\textsuperscript{22} Addressing agricultural subsidies, or limiting the resource drain from low income countries would be much more empowering. The following quote captures this thought, (as well as some ideas in Category 4 and 5).

Queen’s students who go overseas will become critical of the development model and understand their limited role. It will give them an excellent experience that they can return to Canada with and discuss with this community. It’s not all bad, but why do the privileged need to get more privileged? They are far better off fighting the injustices that keep the poor, poor. ... Going overseas is not intrinsically bad — the warlord in Nigeria who is getting cut backs from Shell is not the source of the problem. You can work to change the system from many places, but the best work is to try to end exploitation. (Ca6)

To ignore root causes of underdevelopment, we are just part of the problem that gives rise to deep suffering. Concept 5, later on in this chapter (Section 5.5), will deal with the balance of addressing root causes and surface problems.

The hierarchy of ways in which the international humanitarian engineering placement is understood is important, because

1. this placement could be a critical component of a humanitarian engineering program
2. the ethics of sending students abroad is directly related to the ethics of teaching engineering students about their role in providing engineering solutions in marginalized communities.

\textsuperscript{21}It is practically impossible to discuss a completely independent community, especially when we note that the entire planet is affected by the emissions from industrial processes.

\textsuperscript{22}See [32], for example.
This hierarchy suggests that it is important to weigh the many negative impacts placements can have against the possible benefits.

5.4 A local humanitarian engineering placement

The fourth concept, a local humanitarian engineering placement, flows logically from the last topic. Initially, I categorized this concept with the international placement, but it quickly became obvious that the interviewees perceived the two concepts differently.

The point of this section is to describe the different ways in which the local humanitarian engineering placement was conceptualized in the data. Through the fieldnotes and research interviews, a pool of understanding was collected. For this case, the hierarchically inclusive relationship is given in Table 5.4.

To begin with, it is necessary to properly define a local project. A local project will involve working as a Humanitarian Engineering student in the same community, usually urban, in which that student lives, works, or goes to school. Many interviewees were drawn to discuss development projects with Canadian First Nations people. The condition of many of Canada’s First Nation reserves is an important point for discussion as many of our aboriginal people have been efficiently marginalized, but for non-Natives to consider this as a location for a local placement would be to undercut the premise behind the local placement: the local placement is intended to be about the potential work in one’s own community. It is acknowledged that some of the engineering students may themselves come from a First Nation reserve, but for the sake of this dissertation, an engineering and development First Nation’s project does not fit into the category of a local project. In many ways, opportunities to cross borders into an aboriginal community in Canada for the sake of a development project are very much like the opportunities to go overseas for international projects.
CHAPTER 5. RESULTS AND ANALYSIS

The two categories into which I have divided the humanitarian engineering placements into (international and local) do not include all possible locations for a placement. I am not suggesting that placements must be either local or international; a placement in a marginalized community in another Canadian city could be very appropriate, for example. This thesis only presents data for local and international placements because there was no data for other placements.

<table>
<thead>
<tr>
<th>1</th>
<th>Local engineering and development projects are impossible or unnecessary</th>
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<tbody>
<tr>
<td>2</td>
<td>Local projects are possible, but with significant obstacles</td>
</tr>
<tr>
<td>3</td>
<td>Local placements are possible and important because of the need</td>
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<td>4</td>
<td>If there are to be placements, there must be a local component</td>
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Table 5.4: The outcome space for the fourth phenomenon: A local humanitarian engineering placement

There are several aspects of this phenomenon that make it unique in this study. First of all, it was relatively easy to separate the perceptions into different categories. Also, the concept of a local placement was not something that some people could easily relate to. In several cases, there was very little to talk about as the interviewee had few, if any thoughts about the concept. Also, there were only 4 categories, as shown in Table 5.4.

5.4.1 Category 1 - Local engineering and development projects are impossible or unnecessary

Unlike the pool of understanding for an international placement, there was evidence that the local placement was not seen as a beneficial endeavor. In fact, in the first category, a local engineering placement is perceived to be impossible or unnecessary. It was suggested that curriculum should focus on international placements as local placements could not provide the same benefits to the student, the institution, or the host community.

First of all, local needs are seen to be real, but not something that the engineer can
address. While there is much work that can be done in marginalized local communities, this work is not perceived as appropriate for engineering students.

For an engineer, the role in the local is difficult because we have a lot of services already provided, so we are not dealing with the same kind of physiological needs, for the most part in Canada. The failure of someone to take care of their physiological needs, is not a technical problem — it is often a political problem. So the role that engineers can play locally, I would argue is less. As citizens the role is critical. If the root cause is political, the only thing that is going to change that is citizen pressure. So, yes, as citizens, they can create change. As engineers, I don’t see too many opportunities. (Ca2)

Local projects are not useless because they will show the great inequities, but I fail to see what engineers can meaningfully contribute here. (Ca2)

Other interviewees conveyed the same understanding. One said that if local placements were to succeed, appropriate partners to work locally needed to be found, but that

Engineers who you’d want to have as a role model may not be engineering-focused. (Ca3)

In another interview, when the initial question about local humanitarian engineering work was asked, the interviewee equated the question with how we as engineers should live responsible lives — with integrity and with a strong community focus. He said that engineers need both to live an ascetic lifestyle, where he or she is aware of our environment, neighbours, and social injustices, and to work to make more efficient, less resource-consuming devices. When I asked the question again, making it clear that the local work was for an engineering placement, the interviewee said that

Engineering implies the design of things. And locally, it is really difficult to find well defined problems that involve design and not construction because
construction can be done so much more competently by qualified personnel right here in Kingston. So, the problems that come along will be precious few and far between that lend themselves perfectly to that kind of curriculum. ... There aren’t enough of those well defined problems to satisfy a large number of students. (Ca13)

In the previous quotations, the local placement was seen as a challenge to be fit into the domain of engineering. The following quotes suggest that the local placement is also perceived as unnecessary in light of the much greater need elsewhere. Again, in this understanding, the focus shifts to international placements.

There are much more poorer communities in real need in Africa or Asia or South America. (Ca9)

Let’s tackle the big issues first. Life here in Canada is pretty good for everybody. Even the people who aren’t doing well. It is still a lot better than others in a poorer country. My passion is more for the international side where there are major pressures on people. (Ca8)

This was a common perception expressed in many of my discussions in Ghana as well. The needs in Africa were seen to be greater and more important, and for Canadian engineers to do humanitarian engineering placements in Canada was considered ridiculous.

Whatever you see in a marginalized community in Canada, you will see a thousand-fold in Ghana. So in that sense, even from a value for your money perspective, and from my selfish perspective where I’d like to see people think about our problems, then they should come here [to Ghana]. (Gh9)

It is cheaper to place a student in a marginalized community in Canada, and for this reason, a local placement could be appropriate, according to the understanding in this category.
Ca9: Local placements are good if there is a problem in affording to sending someone to Africa. Then maybe you should send someone to an Aboriginal community within Canada.

JDJV: What about a poor community in Northern Kingston?

Ca9: Their needs are real, but there are much more poorer communities in real need in Africa or Asia or South America.

5.4.2 Category 2 - Local projects are possible, but with significant obstacles

In this second category, local placements are seen as a possibility, but with significant obstacles. In this understanding, the local project is seen as a weak alternative to the international placement. Engineering within local development projects has potential, but the engineering focus is seen to be limited. Positive elements were sometimes identified, but typically the tone was hesitant.

It always has to be done with the sober reminder that the best solution is the simplest one, even if it is the less glorious one. So, whenever you can find something that fits the bill a shorter distance away, that is your ideal solution. I can’t on the top of my head think of any good examples. ... When you’re looking locally, to fill the same mandate, you are going to be grasping. (Ca13)

If you can pull it off, then it is a good thing, but it is a very difficult thing to pull off. When talking about the homeless, the obvious solution would be building shelters. Then we’ve got second year engineering students doing what? Why wouldn’t you just sign them up with Habitat for Humanity? But remember, they’ve just stepped out of a class learning vector calculus. (Ca13)

It was obvious that asking about local projects took some interviewees by surprise:
JDJV: What would you think if some of the students stayed in Kingston, or Ontario for their placement? Is there any value in that?

Ca8: That’s a good question. (pause) It would be a very, very different kind of situation. When you go to a different country you go in expecting that, ‘I’m in a different culture — there are a lot of strange things here, I need to adapt.’ It kind of puts you into a different mindset than working in your own community. I think that at the end of the day, you could probably have positive results here too. ... I do think that it would be a different type of experience.

Ca11: ... And of course these placements can be right here in Canada.

JDJV: What about our own city? Can we have these placements in Kingston? There are a lot of marginalized and poor people right here in Kingston.

Ca11: I personally don’t see that as achieving the same goal. It is a social experience, but (pause) depends, for example one goal would be to give some attempts to modify some housing policy to make it more affordable.

JDJV: So you do see potential there?

Ca11: I do see potential there. There are things that could be learned.

Canadian university students often still have to cross borders to work with marginalized people in their own community, which may be difficult for a student who has not experienced poverty before. One interviewee suggested that getting students to immerse themselves in an unfamiliar part of their community is another potential problem.

If they are here and aren’t immersing themselves [in their own community], it would be hard to immerse them. Ca13

While there are fewer logistical hurdles for a local placement, many of the challenges are similar to those discussed for an international placement in Category 5 in the previous
section. Local placements can easily be paternalistic or undermine a community’s capabilities, for example. The local placement is seen to be possible, but not without challenges. In this category, the real engineering aspect is seen as weak, but advantages also exist.

5.4.3 Category 3 - Local placements are possible and important because of the need

In this third category, the local humanitarian engineering placement is seen as necessary and important not only because of the presence of marginalized communities locally, but also because it is within the realm of engineering. While it is less obvious to see how engineering can be used locally, it is important to think broadly about engineering. By defining technology as a practice of “how things are done around here,” it is much easier to see how engineering can improve any community.23

First of all, several interviewees easily identified the benefits of local placements:

Work within your own community. That helps a lot. It makes sense for so many reasons. It saves on having to send people to other countries to have to do work, and you get to know people in your own neighbourhood. (Ca7)

People should take care of their own communities and lead by example. ... I want to keep contributing to my community, where I know people, where I know what is going on, where I am intimately connected to my community and I can make it better. (Ca12)

You don’t have to go across the world to immerse yourself in a different type of world — there are different worlds here too. You can learn a lot by worrying about the people who live on the other side of the city. You don’t have to go far to find people in need. (Ca8)

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23 Ursula Franklin stresses the importance of this broader definition of technology, in her Massey Lectures, *The Real World of Technology* [19]. Smillie gives a similar definition: “Technology is the science and the art of getting things done — through the application of skills and knowledge” [2].
Secondly, the following quotes indicate that engineering skills are perceived to be necessary.

There are marginalized communities everywhere that could benefit from some engineering thinking to solve small problems. (Ca5)

JDJV: Are you concerned that the local placements won’t be technical enough?
Ca10: What kind of engineer are you if you can’t find a technical problem? There’s no end to it. Just retrofitting a house to make it more energy efficient, for example.

[Engineers] could work on ways to help with housing; provide low cost energy sources, heating; better forms of insulation; more environmentally friendly shelter. I keep going back to the basic shelter — locally, that is the biggest problem. And a lot of it is not necessarily engineering, but involvement from engineers would be useful. (Ca17)

The quotes above are well aligned with the principles of the Professional Engineers of Ontario. In fact, the Code of Ethics that governs the PEO states that engineers have a “duty to society, which is to regard the duty to public welfare as paramount, above their duties to clients or employers” [25].

The following quote suggests how local placements fit in with a broad, and comprehensive approach to humanitarian engineering placements.

Personally, I don’t see any difference between international and local placements. I wouldn’t distinguish based on the location of the placement — it is what you are doing on the placement that’s important. ... Humanitarian engineering cannot just be in aid of international development. I prefer the term ‘marginalized community’ because then those marginalized communities can be here in Kingston, they could be across the country or international.
Marginalized communities could even include the disabled or the elderly, as well as the impoverished. ... Humanitarian to me doesn’t have the word ‘international’ in it. It is often conceived to be international, but it doesn’t have to.

(Ca5)

One interviewee talked about how a local placement would help engineers see the world from the perspective of the marginalized — the poor, the elderly, and the handicapped. So often the city is not designed for these less-visible people. Working to reduce the challenges of the marginalized will, in turn, make a better engineer. Another interviewee spontaneously reached the idea of a placement on the streets of Kingston without my even suggesting that it was something that I wanted to talk about. This interviewee proceeded to talk about the power in breaking down prejudices and understanding impoverishment. This too could lead to the creation of a better engineer.

JDJV: And what would an engineering placement look like on the streets of Kingston?

Ca17: There’s all kinds of programs and all kinds of people who need help. They could work with them. And they’d see that circumstances changed a lot of people’s lives. They are not just lazy, drug addicted, drunkards who don’t want to work and are basically classified as losers. That’s not the way it is. If you look at most of the people that are in difficulty, you’ll find tragic upbringing, abuse, broken families — you wouldn’t expect them to grow up any other way. If you are in the environment working, you start to see that.

There really are some great people. You’ll realize that we are all the same, just some of us have had more breaks.

Local placements were seen to have merit, yet still involve challenges. Working with the locally marginalized requires students to step out of their comfort zone. These next two quotations touch on this.
JDJV: Can we use engineering placements to work in marginalized sections of Kingston?

Ca10: Yeah. It would be great. It’s hard for me to separate that kind of work and just living. We should be serving people like that. But there are a lot of obstacles too, right. Poverty breeds crime and crime is dangerous. It’s hard to be in that environment.

JDJV: Do you think it is legitimate to have an engineering placement here in Kingston? Working as engineers in this community?

Ca12: Yes, but they need tools. For instance, there were supposed to be two students [from a class at Queen’s] who were to come [to work at a local community organization]. They came once and then they stopped returning my emails and phone calls.

JDJV: So what kind of tools do they need?

Ca12: I think that they didn’t understand. (pause) I think there is a big class divide. ... Only lower income people volunteer there. They feel comfortable there. They think, ‘wow, this place is just like me.’ It’s about matching people well. It was a great idea for [the university students] to come out, but they didn’t feel comfortable. ... We focus on making our place somewhere where low income people feel comfortable because low income people don’t have anywhere where they can feel comfortable. ... I don’t know why they didn’t come back, maybe they got busy with school, or forgot about it, but I got really mad and now I have a bad opinion of them. So I think it is important to start with a good solid precedent and not just start with a fun little idea that blew up in our faces. It just created some bad blood. ... So, in terms of placement in the community, I think it is a great idea. I’m a little bit discouraged because we had the idea and [it didn’t work].
This category suggests that engineering skills can be used in local marginalized communities. Another way to understand this category is to ask: If our local problems are not technical, what do we need more engineers for? It is true that technical solutions can be useful for solving a range of large scale problems, like air pollution, but if engineering cannot solve local, community challenges, the field of engineering cannot be deemed to be very utilitarian, nor can it claim to have done its duty to public welfare. Obviously, engineers are useful for driving the economy, but it is short-sighted to view the economy as a means unto itself.

Why do you need to go overseas? The white man’s burden is over here. ... We need to focus on our own community. Engineers can help people getting off the grid and help design alternative communities and essentially bring the local structures down gently. (Ca6)

A broader definition of technology as a practice seems to be critical to this category of understanding, and perhaps to a more inclusive understanding of engineering in society. The following quote voices some similar sentiments:

It is very important because engineering students have certain skills. They are creative skills, innovative skills. They may not do engineering things, but they can suggest a number of things to which that community can benefit. (Ca15)

Finally, the need for local development work is often seen as a result of postdevelopment. This is not necessarily a call for the end of modern engineering, just like appropriate technology does not call for the end of high-tech solutions. An increasing focus on local communities simply requires a more conscious awareness of the forces of globalization and technical progress.
Postdevelopmentalism which entails the proposal of some new principles like thinking locally rather than globally, living more simply in material terms or seeking more spiritual lives rather than worshiping the latest fashion but also finding truth in modernism and modern discoveries like machines and hospitals which have their beneficial uses. [47]

5.4.4 Category 4 - If there are to be placements, there must be a local component

In the final category, the local humanitarian engineering placement is considered to be essential — especially because it will help put the international placement into context. International and local placements complement each other. It is often easy to see the needs of others in far away places, but hard to see needs closer to home. Similarly, international travel can help one see the challenges and weaknesses of their own community. In the same way, working with the marginalized locally can help one see the injustices globally.

Students should be forced to ask: What does the community need? It’s pretty hard to ask: What does the world need? We can’t really go over to Iraq or another country and then tell them that they don’t need a big screen TV or a cellular phone because we can’t dictate to them. It’s hard to figure out what to do in the world, but in our communities it’s easy to see the elderly living in rooming houses and they’re not really happy, and [they’re] lonely, and we could build a recreational or community centre. ... Thinking this way helps everyone. (Ca7)

Part of what [one school] tries to do with their students is to really connect the international to the local, so there is a sense of continuity between the neighbourhood that starts the minute you step out your front door, and the neighbourhood that includes all other people on the planet. That sensibility can really affect the choices that get made around curriculum. (Ca1)
Development has to be framed as something that has to be done here, before taking it elsewhere. (Ca4)

If we are really interested in inequality, we need to spend time with the marginalized. (Ca12)

First of all, you need to work in your own place. Learn from your own place. It is always said, when people go to do development work overseas, the first question they ask is, ‘What are you doing for your own people.’ And if you are not able to answer that, your credibility goes right down. So you need to say, ‘Yes we have problems in our own place, but we are trying to address them.’ (Ca15)

According to this category, the local placement complements other placements. Thought experiments about the merits of the potential of a local placement are useful in putting humanitarian engineering placements into perspective. This type of reasoning often caused me to wonder why it is easier to think of how engineering solutions can solve problems in Africa. Why is it easier to see the flaws of other communities? Perhaps the problems we face are too much a result of our own decisions. Or perhaps we are conditioned to think of others far away as more desperate, while the marginalized in our own communities have not worked hard enough. A piece of ancient wisdom suggests that it is easier to see the speck in the eye of others than to notice the large obstacle in your own eye.24 Certainly the nature of the needs in low income countries is very different from the needs in Kingston, Ontario, but the main point made in this category is that some significant self reflection is critical. The following quotations capture this idea.

24The Biblical passage, Matthew 7:3-5, quotes Jesus: “Why do you look at the speck of sawdust in your brother’s eye and pay no attention to the plank in your own eye? How can you say to your brother, ‘Let me take the speck out of your eye,’ when all the time there is a plank in your own eye? You hypocrite, first take the plank out of your own eye, and then you will see clearly to remove the speck from your brother’s eye.”
We always think of remote people as desperate, but are callous enough to not see the desperate people here. (Ca11)

The hallmark of someone who is really engaged is someone who is present in their communities. ... We see mission as something that happens over there and then I come back to my regular life. If we are going to talk seriously about changing the way we live and living changed lives in changed communities then we have to do a little bit better than that. We have to be a little more intentional and present and engaged. That part of what we are interested in doing, we are interested in doing on ourselves and in our communities. And there is a potential that the more work we do locally, the more we can see the effects of it. ... Secondly, we can see the influence of our privilege on the deprivileging of others when we are engaged in our own communities. Those links are a lot harder to see internationally I think, because of the cognitive dissonance or the conceptual problem is a lot more challenging. (Ca1)

A quote from Tim Broadhead\(^\text{25}\) captures the idea of this category. This quote very nicely fits the definition of humanitarian engineering used in this thesis: it alludes to the ideas of appropriate technology as well as a critical analysis of technology.

As citizens we have a privilege to support the South, but we have the obligation to change the North.

In practice, it would be difficult for a student to have both an international and a local placement, but the idea here is that the sending institution capitalize on this complementary relationship through having its students involved both internationally and locally. Ideally, upon return, all of the students would report on their experience and hopefully learn from each other.

\(^{25}\text{From his keynote address at the 2007 Engineers without Borders conference in Calgary, Alberta. Broadhead is the president of J.W. McConnell Family Foundation, one of Canada’s largest charitable foundations.}\)
Throughout this category, it is clear that there is some tension between the appealing international placement and the less obvious and more mundane local placement. This tension has deep implications when it comes to the administration of a humanitarian engineering program if it is to include a placement. Some important issues regarding what the scope of engineering should be also remain unresolved at the end of this category. How broadly are we willing to define engineering?

5.5 Engineering as a means to address the root cause of marginalization

The last concept to be presented in this chapter is the role of humanitarian engineering in tackling the root causes of social inequality and injustice. There is much written about the need to channel the vast resources of volunteerism toward social change for a more just society, and this last concept will deal with how engineering work could fit into this transformation process. The goal of this section is to describe the pool of understanding of how humanitarian engineering is perceived on the charity/justice spectrum. This concept is arguably the most abstract one covered in this thesis, but could have significant impact on the understanding of the role of the engineer.

A medical analogy was often useful while discussing this concept. A band-aid, while it by no means gets to the root cause of the bleeding, is often a necessary implement. Yet, if our health system only worked with symptoms and treatments, effort would be in vain; there must be some focus on prevention, such as inoculation. Charitable intervention is often seen as dealing with surface or band-aid problems, while working to resolve injustices gets at root causes. The charity model often deals with altruism; social justice frequently gets political. Table 5.5 maps some extremes of these two ideals. The necessary quest for this study is to find out where on the spectrum humanitarian engineering fits best.

26See ‘From Charity to Justice,’ by Marullo and Edwards[158], for example.
Table 5.5: Polarity of response to marginalization

<table>
<thead>
<tr>
<th>Charity</th>
<th>Social Justice</th>
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</thead>
<tbody>
<tr>
<td>Surface</td>
<td>Root</td>
</tr>
<tr>
<td>Do for</td>
<td>Do with</td>
</tr>
<tr>
<td>Client</td>
<td>Partner</td>
</tr>
<tr>
<td>Hierarchy</td>
<td>Differential equality</td>
</tr>
<tr>
<td>Easier and profitable</td>
<td>Harder and requires effort</td>
</tr>
<tr>
<td>Moral</td>
<td>Political</td>
</tr>
<tr>
<td>Status Quo</td>
<td>Transformation</td>
</tr>
</tbody>
</table>

Table 5.6 presents the hierarchy of the pool of understanding of the potential engagement of engineers wishing to address root causes of marginalization. It is worth noting that issues that link root causes and humanitarian engineering came up in many different places during the interviews and often at times when the interviewee was not prompted. Again, some respondents had a lot to say on this concept, while others were less prepared to discuss the phenomenon. There is some overlap between this and all of the previous phenomena, but it is addressed separately because it is critical to the central proposition of this thesis.

| 1 Technology cannot address the root causes |
| 2 Engineers can only address the symptoms, but still have social merit |
| 3 Humanitarian engineering can address root causes, beginning with discussion |
| 4 Humanitarian engineering must address root causes |

Table 5.6: The outcome space for the fifth phenomenon: Engineering to address the root cause of marginalization

There is a need to briefly discuss what is meant to be political, because it is often said that true social justice requires political engagement. In this case, it does not necessarily imply supporting a specific political party. In his article entitled *Engineering and politics*, Ian Wright postulates three layers to understanding political action. It is the third item in the
list that is the most important political response for social justice, and one that is available to all people.

1. Politics as the actions of a central (federal or state) government.

2. Politics as the involvement in local government or organization or company.

3. Politics as the process of influencing political decisions or policy in all areas through letter writing, activism, or other forms of lobbying [192].

5.5.1 Category 1 - Technology cannot address the root causes

In the first category, humanitarian engineering is seen as something that cannot solve the root problems of inequality and injustice. Like the first categories in Concept 1 (the social role of engineering), engineering is seen as a neutral endeavour, and the engineer’s primary role is to delight in the technical challenges, which can only address the symptoms. This is especially obvious when considering international engineering development work, where the engineer’s role most readily deals with the band-aids.

I hold the position that the root causes in a lot of cases is first world exploitation of the third world. Technology cannot really address that. Technology can only address the symptoms of that power relationship and unfortunately I don’t think any kind of revolution in the way the first world deals with the third world is imminent. In the mean time, technology can address those symptoms. (Ca4)

Engineers generally focus on band-aid solutions. That’s what we do. The role of the engineer is only to provide band-aid solutions if they want to be involved in international development. (Ca2)
This understanding was not limited to international development work, but to engineering and development in general. The following quote was not given in the context of international development.

I don’t see my role as an engineer to have anything to do with social justice. I don’t think I can do that. I don’t think I’m qualified to do that and I don’t think I can direct my energy to that. There’s only so much energy I have. (Ca5)

One interviewee suggested that the engineer’s training is insufficient to deal with root causes of social issues. This next dialogue excerpt implies that engineers need to remain firmly in the field in which they were trained.

JDJV: Is one of the problems [in Engineering Education] due to the lack of teaching social impact and that the problem solving focuses mostly on technical solutions?

Ca10: Yeah. I guess. It’s very rare that you find an engineer who is thinking like this. Generally it is lawyers: social engineers. They are the ones who are supposed to structure society in a way that is equitable. ... Now the complexity of the system has grown so much that they can’t keep it in check and engineers are looking for technological solutions. Engineers shouldn’t be looking to solve social problems with technical solutions. They shouldn’t be looking to solve them at all. They should be looking to solve the actual technical problems. Once they get into the realm of social engineering they are just beyond the range of their expertise and we’re just not equipped to deal with it.

Similar to the former quote, the following quote picks up on the complexities of our social structures. The root cause is identified as human gluttony, but the underlying solution to the complexity is for engineers to focus on developing technology.
To me, I know it doesn’t matter what you develop, human beings will do terrible things with it and maybe will do wonderful things with it. And that is out of my control. If I have to second guess everything I do because someone might do something bad with it, I can’t do anything and I guess I just stop. ... Do we want a government who says that you can’t do this or that? No, we don’t want that either. This stuff is all so complicated. The unfortunate thing is that human beings are greedy and selfish and all of those things. I don’t think engineers are going to solve that. (Ca14)

Another common understanding that was expressed in this category is that engineering should not be politicized; politics should stay out of the engineering classroom.

When it comes to politics and the university, there should be some impartiality. A university needs to be a haven for free thought. (Ca10)

JDJV: So what I am hearing you say is that engineering is not political and that we should focus on our technical challenges.

Ca13: I think it would be dangerous to make it political.

The final quote, which connects the root cause with the current power hierarchy, like the other quotes in this category, states that the engineering student can do very little work with the root causes.

The root causes are beyond the engineering university student. ... The power structure is there and it is deeply, deeply embedded. (Ca10)

5.5.2 Category 2 - Engineers can only address the symptoms, but still have social merit

In this second category, humanitarian engineering is still seen to only be able to address band-aid problems, but this is seen as an important role in the bigger picture. While the
first category focused on what the engineer cannot do, this category has a focus on what the engineer can do. This understanding is dominated by reductionist thinking, where the engineer is seen as one piece in a big puzzle. Engineers can only contribute to their job, but if everyone does his or her job appropriately, we will move towards a more just and equitable society.

JDJV: Can engineering work get at the root causes [of marginalization]?

Ca13: As I’ve said before, one of the things that keeps me both humble and sane, is acceptance of my skill set and how it fits into the bigger picture. While it is important to be aware of all of these issues, I also have to accept that I’m not nearly as thoroughly trained to deal with these issues as other people.

... Let’s look at the politics students. I know the definitions of democracy and hegemony, and different economic systems. I know the difference between a political system and an economic system. But they really know the difference. They don’t have the technical understandings of science that I have, but they know philosophy really well. So, I’m content to let them dig up the social issues, write about the social issues, draw conclusions, and then, I’ll look at their summaries, their bullet points and with my more shallow understanding of these topics, competently recognize what I can do to deal with them. It is not my job to be a renaissance man. It is extremely difficult to educate anyone to be a renaissance man. But if I can have enough of a foothold in various disciplines that I can understand what other people are talking about and I can respect their competence in those spheres, then we’ve finally got a society that is working as a team. So, I work on what I work on and I’m good at what I do.

This next quote also implies some level of reductionism, but in this case, an engineer must separately consider his or her role as an engineer and as a citizen.

The role of the engineer is only to provide band-aid solutions if they want
to be involved in international development. It is the role of the citizen to attack the root causes, and that is everyone. So, yes, we can partake in band-aid solutions, and if we don’t, others will die, so in a sense, we have an obligation to sustain an already dire situation. We can’t do that indefinitely, we have to attack the root causes, and those root causes are not necessarily engineering related, they are trans-disciplinary causes, societal causes. ... But as engineers, we must focus on the band-aid, all society has to attack the root causes. (Ca2)

In this category, it is understood that it is very difficult to address the root cause with humanitarian engineering, but that a competent and balanced engineer can do valuable things when he or she sticks to their skills. It is granted that band-aids are needed to prevent the victims from bleeding to death.

I think it is a huge mistake to believe that if you can’t change the root of the problem, you can’t do any good. There are too many people who have that attitude. The world doesn’t function ideally and I don’t think it ever will. You have to be adaptive and use your skills the best you can. ... I don’t believe in my lifetime that we are going to change the world, and that global inequity will be solved. I don’t see it happening in my generation. You either say, if you can’t fix the whole problem, then you should leave it alone and stay out or you take the attitude that maybe we have something to offer. We can solve a number of significant problems with engineering and development projects. (Ca5)

I spend my energy in applying the band-aids and I think it is my obligation to do that. ... I became an engineer so that I could develop certain tools, skills, and abilities and those are to solve somewhat technical problems and to have an impact whether it is on the safety of someone who is living on the shoreline in Ontario, or someone drinking water in Africa, I believe I have those tools
and skills to help solve those problems. ... Is it putting on band-aids? It is, but do you know what? If all I had was a band-aid, and I’ve cut my neck and it was bleeding, I’d like to stop the bleeding a little, so I might live. So by doing these little band-aids, I think we are having an improvement, albeit small, on a small portion of society. (Ca5)

Again, the issue of how ‘political’ engineering needs to be or can be, is at issue. In the reductionism that must exist for this category, it is important again, that engineering is not too political. An excessively political understanding of engineering works to break down the necessary predefined functions.

The problem, I believe, is that we perceive engineers in an excessively politically biased light. For example, [I have a friend who has a job in energy policy and] is familiar with the smatterings of the sciences behind energy sources, but I’m really well versed in them and she’s much more familiar with the social impacts and the political impacts of those technologies than I am. When she hears I am working on [my current field] she gets really impassioned about it and says it is a waste of time because it doesn’t take carbon out of the system. And every time I say, ‘I’m just a tool. I’m developing technology. I think this is technology that is useful in the right context. I am not going to tell you how to use this technology — that’s your job.’ (Ca13)

In essence, Category 2 states that if applied correctly, engineering can be a part of an equitable, well functioning society, but engineers must primarily stick to their roles. They cannot do everything and must hope that all other sectors of society are competent in their roles.
5.5.3 Category 3 - Humanitarian engineering can address root causes, beginning with discussion

In this third category, the root causes of social injustice are seen as difficult to address for humanitarian engineering, but necessary and possible, and that addressing root causes begins with discussions. There is a great danger if we only talk about band-aid solutions, because it is often necessary to know what is causing a wound. Engineering training must include exposure to root causes and our social location. Engineering and technology are seen as non-neutral in this category, and in fact, it is recognized that marginalization is sometimes caused by engineering projects.

A lot of the marginalized communities are engineering induced. If you look at the Northern populations in Alberta, the effects of the tar sands projects are staggering. So should we be tackling some of those projects? Of course we should. (Ca5)

At the very least, the larger causes must be discussed:

To address the symptoms without addressing the larger cause, you are kind of legitimizing the system and the status quo. (Ca4)

The next dialogues make the same point, but also bring up the issue about education on social location. Working towards the root causes begins with exposure and discussion.

Ultimately if any true changes are going to come, the root causes have to be addressed. [Engineers] should be given the opportunity to explore the root causes by examining the interconnectedness in how we live our lives and how others live their lives. (Ca2)

Ca2: There is great danger if we only talk about band-aid solutions in engineering education. If we only talk about the band-aid solutions, in people’s
mind, it is sufficient. That’s all we can do in their mind. If they are never exposed to root causes, then the band-aid solutions are sufficient. If you don’t know what is causing the wound, all you can do is put a band-aid on, you can’t do anything else. We have to expose people. If we fail to expose people, while at the same time providing them with some means of vindicating themselves from their so called guilt, then we’ve created a very dire situation where people continue doing only band-aid solutions of arguable good, without acting against root causes.

JDJV: How do you expose people to these things?

Ca2: Those are addressed by teaching people about the way the world really works and what their impacts are. If they so choose, after becoming aware of their impacts on the rest of the world, that is their own decision — you can’t force them. But I would argue that most people have a sense of justice and a sense of what is right or wrong and would be inclined to reduce their role in creating suffering around the world.

The following quotes continue to emphasize the problem with solely considering band-aid solutions and the importance of awareness and education. Awareness and education are things that engineering educators can offer.

Eliminating poverty is what you have to do and you don’t do that by drilling wells, but by educating people and by giving them some chance. Helping them to create opportunities and investing in them in ways, like funding, so they have a chance to get started. It has to do with a redistribution of wealth. ... Engineers are as much a part of it as anyone else, but they are not any more a part of it. I guess that humanitarian teaching and through osmosis, engineers will start to be more in tune to discrepancies of wealth and quality of life. (Ca17)

If we make them aware, then of course they will start to think. Then, they
will try to find more out about things and will see exploitation. The require-
ment is in the education, in making them aware. Then, a level of awareness
could help produce more just engineers. And this is in both developed and
developing countries. (Ca9)

Much like the discussion in Category 3 of Concept 2 (Changes to the engineering cur-
riculum), it is critical to find the right balance in engineering between technical compet-
tency, and big-picture thinking. The next quote discusses this tension.

JDJV: Do you think we can address the bigger root causes?
Ca9: Yeah, I think so. We don’t want to make it a big political debate. There
is always a limit. There is exploitation, that is for sure. But to some extent, you
can educate, but you can’t go into too much detail. Don’t want to talk too much
about who is wrong. This is engineering. You don’t want to get dragged away
too much. The important thing is to make awareness — that it is not fair. The
world should be fair. Everyone should have basic facilities. I don’t think with
engineering we can go into that big detail.

The previous quote, again, brings up the idea of politics in the classroom. In this cat-
egory, it is understood that engineers need to be aware of the politics behind things like
resource extraction, environment protection, and corporate operations. The following quo-
tations mention that there is a specific role for politicizing the engineering curriculum,
although there must be a place where different political perspectives are allowed. This
balance has to do with informing on social location, while allowing for various opinions.

JDJV: How political should we allow this to get? Just like the doctor, engi-
neers always seem to be working on the symptoms. Can the engineer be a little
more political?
Ca11: I wish. (pause) I would say we do need. It is a very tough one. But it must be completely voluntary — not a core requirement. It would be counter productive. (pause) You don’t want to force someone with a certain political view. Give a chance for some to open their views through seminars. ... I would simply push as much as possible, things that are dealing with social responsibility. For example: two different categories that illustrate an important difference. One is the issue of public versus private. This is a big issue and many of us have strong opinions, but I would consider that debate, more or less political than ideological and would question favouring one over the other [in the curriculum.] But issues of social justice versus issues of business as usual are also political, but in my opinion are valid issues to be forced in the curriculum because even if you personally disagree, the idea of social justice is important and students should be exposed to it. In this debate, perhaps the devil is in the details, but maybe it is the debate that is important.

JDJV: Does engineering, then need to be more political as well?

Ca15: Political is there. We cannot say that we are not political. You see, everyday, when I take a razor and take a shave: Do I realize from where this razor was manufactured? Do I realize from where the people behind the manufacturing were raised? I don’t. But if I think about it, it is in some developing country, where there is a sweat shop, where they are paid minimum wages and I buy it and use it as my razor. Am I not global? Am I not political? Yes I am. I am supporting that industry. So, I need to be political as well. So, I think in this, we need to understand the politics. So, that doesn’t mean, we go around and take politics courses. But we need to think about how there are people who are being paid pittance while we have a comfortable time eating a burger. So we are political all of the time and I think this we must keep in mind.
JDJV: Can we use the engineering classroom to talk about our interconnectedness and these things that you are talking about?

Ca15: I think it needs to be discussed. This is why I say that in whatever we discuss, we need to look at from different perspectives. Look at it from an environmental point of view. Look at it from a human point of view. Look at it from a political point of view. Look at it from the point of relationships. Does it promote relationships? ... Are we thinking of getting people together or keeping people separate? So in discussing something, we need to discuss it holistically. We can’t discuss everything comprehensively, but at least we can be sensitized. ... And technology needs to be analyzed this way.

The next quote also captures the overriding importance of political will and how it influences engineering and science. It is impossible to completely separate science from politics.

Ca14: It is all political will. ... Look at the whole global warming thing that’s been going on for the last years. Finally the politicians realize that they have to be doing something because the public thinks it is important now. Forget about arguing about whether it is scientifically right or wrong, politically, the tide seems to be turning. And it is totally a political thing if action is taken. So, you can have engineers bashing their heads against the walls, but unless the population agrees with it, programs aren’t going to be put in place. ... So, maybe we need more engineers in politics to point us in the right direction.

JDJV: So, do we need to make engineering more political, perhaps?

Ca14: Maybe. I don’t know. But for me personally, the last thing I want to get involved with is politics. I hide from it. I’m not interested in it. I like my gadgets and my computers. That’s why I became an engineer. Maybe we should publicize more, if you want to save the world, become an engineer.
Maybe we need the marketing to be switched a bit.

Engineers with a sound understanding of our political structures have a good opportunity to influence policy. Humanitarian engineering can best address root causes with this political competency, but yet, as the previous quote suggests, the appeal of the highly specialized society is strong.

5.5.4 Category 4 - Humanitarian engineering must address root causes

In the final category, humanitarian engineering is seen as something that must address root causes, regardless of how difficult it is. This category sees the engineer as an important agent for social change. While it is important for the engineer to be technically competent, he or she must also see technology in a broader context — as a process of how things get done.\textsuperscript{27} Engineers can work for social justice, but it takes a new way of looking at things, including a new way of looking at reductionism in our society. One should not separate her or his career from their membership in a local community and from their interconnectedness with all people — this is the grounding premise of the PEO Code of Ethics.

This final category of understanding also acknowledges that it is impossible for engineering to be apolitical. Any service that engineers provide benefits some and not others. One interviewee shared an experience of teaching the difference between one way and two way data transmission in a computer course. He used an analogy between ancient battles and modern warfare in the Iraq war and subsequently received a letter of warning from the school administration to leave the politics out of the classroom. He said,

You can’t not be political. There is a lot of politics associated with not being political. Everything that is taught is political, it is just that the majority of our curriculum is the politics of the dominant discourse. (Ca6)

\textsuperscript{27}A broader view of technology was discussed in more detail in the previous concept (A local, humanitarian engineering placement).
In international engineering development work, it is hard to work for social justice, as suggested in Concept 3 (An international humanitarian engineering placement), especially when working in an unfamiliar environment. It is too easy to resort to the charity model when working in an unknown community. One interviewee suggested that it would be beneficial to consider a sustainable housing material, but too many market savvy students would want to make a profit by selling the idea to everyone in Africa, without considering the real needs.

At the international level, social justice needs to get political. An outsider can work for a lifetime to provide access to water and energy, but this could undermine a community’s ability to demand these services from a local or central government. It is often not a matter of access to technology as much as it is a problem of political will. Inhabitants of wealthy parts of Kumasi or multinational beverage bottling companies, for example, have an adequate supply of water, while I saw several poorer, urban communities that have minimal plumbing, but often had no water running through the pipes. The root causes of marginalization in low income countries are complex, and action must come from the people who are intimately connected with the community. The following quote captures this thought.

The root causes [in Africa] go back to the days of slavery and colonization and independence and the imposition of power and ideology from America and Russia, and the leaders were probably corrupted before independence even came and they started to exploit their own fellow citizens. But as democratization starts to obtain a tender foothold, a lot of leaders in a lot of communities are beginning to say that we need to get it right. So, social justice is something that we can’t impose, social justice needs to be built from the ground up, by Africans and committed to by Africans. We can’t solve that for them. (Ca16)

At the same time, we do have a responsibility in understanding our interconnectedness
with all people, as discussed in the previous category, even if we cannot impose social justice; our thirst for both resources and consumers puts African nations at service to the rest of the world, for example. A recent article by Caplan suggests that “whatever steps Africa takes, unless the West radically changes its role, few positive results can be expected” [59].

We can’t keep trying to protect the portion of the rich. It’s not just to make me safe. It’s not fair either when others don’t have anything to eat, drinking water, or a house to live. (Ca9)

The search for solutions to root causes internationally is difficult, it is necessary to also talk about working as engineers in enabling social justice on a larger scale. Marullo and Edwards, in their paper, ‘From Charity to Justice,’ suggest that not only does the charity model fail to create any real changes, it creates a risk of burnout. As the current younger generation has a strong desire to create positive change, that energy must be nurtured and sustained. “We run a risk of turning well-intentioned young people into cynics and burnouts if we do not heed the warnings” [158].

While charity work is essentially easier, working for social justice will yield more lasting and satisfying results. More importantly, however, it is necessary to work for justice because it is a matter of long term survival, as said by one interviewee:

We live in a time of great uncertainty — the system is falling apart. Fighting these root causes is everything. The root cause of inequality and exploitation is the same force that threatens our own existence. In essence, this is a matter of survival. (Ca6)

A general thought and question that came up in many interviews and conversations is whether or not true social justice is really attainable. The important point, for this category

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28Marullo and Edwards give some statistics to support this statement, which agrees strongly with several informal surveys completed at Queen’s University. One interviewee said, “I find it very refreshing that the students today have a very refreshing attitude towards the world. We have created a lot of problems and they do want to make a difference and make changes. They want to solve the world’s problems and I hope they always have that attitude. The desire is there” (Ca5).
of understanding, is that it is the right thing to be working towards. Several interviewees suggested that root causes could be addressed by either community action or simple living.

As soon as you try to change a system, you get unforeseen problems. Everything we do is so magnified by economics. What really needs to happen is that people live more simply. (Ca10)

There is no simple solution. The solution is withdrawing and everyone withdrawing simultaneously. But as long as anyone stays in the system, [the power structures] still have power. We all need to withdraw. When there is nobody at the bottom of the tower, the people at the top of the tower will look really funny. We need to elevate the image of the simple, withdrawn life. (Ca10)

Individual lifestyle decisions are not enough, but are an important part of living with integrity. There are only so many things that policy can do, as governments have their own interests. The search for greater social justice requires leadership and activism from the people. People want to have a positive impact, but are they willing to be radical enough to be a force of change? Seeking community and common cause are necessary components on a path for good and sustainable human development.

The kind of things that most concern me are how do we mute any paternalism that comes along with our preconceived notions about there and here and us and them. ... Part of what is important with this sort of curricula is the problem of othering — where the impetus to serve is the otherness of the other, as opposed to the impetus to want to work with people is to actually live in community with them, live in a common way with them. The difference is between the relationship of charity that keeps the two others, othered, versus a relationship of common cause where people are working together and this is where development happens: when people are working with people and not to people. (Ca1)
According to this final category, true human development occurs when our desire for change brings us to a place where we can find commonality with others. Formulating effective political change strategies that build on local initiatives, yet contribute to large scale political and economic change remains a major challenge in seeking greater social justice. Thus social justice is connected with a desire for change that recognizes a common humanity; engineers, as technical members of society, have a necessary role.

The hierarchy presented in this section is of importance because it deals with ways to respond to marginalization and injustices. When it comes to young, enthusiastic students, it is essential to offer paths to real change which can only occur through challenging hierarchies and working against the status quo, as opposed to surface approaches which rarely help and often harm. The very real challenge of adjusting oppressive and confining social structures and seeking commonality with others is exciting and adventurous, and adventure has great appeal to young, engineering students.

5.6 Lessons learned in Ghana

As discussed in Chapter 4, a crucial component of the data was collected in Ghana during the summer of 2007. Most of the data was collected in urban areas, but there were a couple of opportunities to spend time in rural Ghana as well. Ideas and quotes from the fieldnotes and interviews were presented in the previous five sections, but there is a benefit in consolidating some of the ideas about engineering, technology, human development, and society that were observed in Ghana. The desired goal of this section is to shed light on the connection between engineering, and both globalization and international development in the context of a specific low income country. It is important to note that the commentary presented here is based on my personal but limited interactions, and is not necessarily objective truth. Appendix F gives an initial field report on the same topic that

29 I conducted interviews in Accra, Kumasi, and Tamale, the three largest cities in Ghana.
was prepared upon my return from Ghana.

This section is an important part of the thesis because my experience in Ghana, much like my experience in Nigeria as a child, has helped shape my bias. My conclusions have been influenced by the observations discussed below.

5.6.1 Engineering skills to improve welfare

The first important observation is that two ideas were almost universally held among the Ghanaians with whom I interacted; I did not speak to or interview anyone in Ghana who did not express these two thoughts.

1. There is a great need for engineers to focus on social issues.

2. There would be a benefit for Canadian engineering students to come to Ghana to provide engineering skills.

The first point, which was also commonly seen in the Canadian data, was held by engineers and non-engineers, professors and students. The general opinion on this issue is that all engineering students must learn about the interconnectedness of technology and society, especially in how it relates to poverty and development. One Ghanaian interviewee said, “The engineer must also be a social scientist. If they aren’t, they are not useful for our people” (Gh13). Words like ‘holistic’ and ‘interdisciplinary’ often came up in the Ghanaian interviews, even more so than the interviews conducted in Canada. When another interviewee was asked about engineers working with the most impoverished, she said, “Not only is this a good idea, it is a necessary idea” (Gh2). One NGO worker who was involved in several engineering projects said that “The social aspects make or break a project” (Gh14).

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30 This is an interesting comment in light of the fact that many of the traditionally trained engineers have historically gone to work for large, foreign owned resource extraction companies.
The second point stands in direct contrast to many interviews in Canada, where many negative aspects of short-term, cross-cultural humanitarian projects were highlighted, as seen in Section 5.3. There were few perceived problems (outside warnings of logistics or safety) with engineering students from Canada travelling to Ghana with the intention of helping. “I see no problems,” was a common refrain.

I was a little bit unsettled with the lack of variation on these two issues. I wondered if it was a sign of my interviewing style: perhaps I was not able to draw the real opinions out of the interviewee. Unlike the individualistic ideals that are embraced in Canada, Ghana’s culture is much more communal in nature [193]. Opinions outside of the accepted norms are typically discouraged, and perhaps my interviewees were giving the answers they thought I wanted to hear. This must be considered when considering the data from Ghana, although there are plenty of examples of useful variation in other parts of the interviews.

Another reason the Ghanaian data supports the placement of Canadian students on development projects with such enthusiasm may be because of the perceived lifestyle in the West. While Ghana was seen to have a great need to ‘catch up’ to the West, Canada was seen as a country with all of its material needs taken care of.31 Once a country does not have to worry about material goods, it makes sense that its citizens work to help others. The following quotation captures this idea.

JDJV: What thoughts come to mind when you think of the engineer in the role of someone who is trying to reduce poverty and increase social justice and provide services for people who are the most marginalized? Is that a direction that engineering as a whole should be going?

Gh6: Engineers have to provide services for everybody. (pause) Let’s be realistic. If an engineer isn’t going to be paid, why would he do it. If he has extra money, fine. There are American doctors and engineers who come to

31 The term ‘catch up’ was used throughout the Ghanaian media, and I heard the term used almost daily in conversation with others.
work with the poor, but they are coming from a society where their problems are taken care of. Really, their problem is not survival or money or otherwise and that is a different issue altogether. So, if you come from a society where the basic needs are met and people really want to find other things to do and they really want to solve some other human problems. That is a different issue altogether.

In Ghana, what is the role of the engineer when the basic roads are not built. When there are no roads, no effective transportation? What does he do? He has to solve that problem. For me it is a different question if some doctors or engineers from the U.S. have felt that they should come to Africa to help, that is a different story. I think that is a business for the individuals involved and the society as well.

5.6.2 Poverty and global politics

If North America is seen as having great wealth, Ghanaians generally see their country as having great poverty. Another important lesson from Ghana is that their poverty and global politics are seen to be deeply intertwined. First of all, poverty was seen to be a result of changing social norms. Traditionally, the Ghanaian culture has been egalitarian, but as the demographics and the economics of the country change so rapidly, this is also changing. One interviewee said, “When we have money, we never think about the poor anymore. We used to, but now we think too much about catch up [to the West]” (Gh2). A similar comment: “It is in our culture to help those in need, but now we see many people rise up and not help” (Gh5). A young Ghanaian engineering student (whom I met after he initiated a meeting with an Engineers Without Borders volunteer) told me that he would desperately like to work with the poor, but he did not know how. “The opportunities just aren’t there” (Gh3), he said.

Another way in which impoverishment is connected to global politics is through the
changing markets in Ghana. Many traditional industries, such as textile and food production, are being replaced by imported goods. Toilet paper is from China; sugar covered peanuts are from Malaysia; used clothing comes pouring in from North America. A local engineer said, “Africa doesn’t make anything themselves anymore, and now we prefer things from far away. This is very bad for our people” (Gh1). I was able to visit some local entrepreneurs in Kumasi and saw a beautiful stove that had been designed and built locally, including the cast burners. I was told that the stove would be transported to Accra and a label saying, ‘Made in Italy’ would be tacked on so that it would be more marketable!

The West is seen as a land of great riches and opportunity; in turn, Western technology and culture are coveted. Television, newspapers and the internet spread images from the West. One interviewee said, “Africa is trying to use technology and mobile phones to catch up. We cannot catch up — we’ve become consumers. And we are addicted” (Gh1). Much like in Canada, many people are drawn to the opportunities and the appeal of the
globalized culture, but others are greatly concerned. There were many people who talked about how Ghana was moving in the wrong direction.

Ghanaians who can identify the problem feel very paralyzed. There are too many external influences and too many outside countries have too much control. And the media is strong so people don’t see the craziness. ... The environment and poverty is worse than before and people have to work very hard to make things go. (Gh1)

The dichotomy between rural and urban living is a topic of great importance in Ghana, especially because of increasing mass urban migration that the country is experiencing. I witnessed and participated in many conversations about whether the rural Ghanaians have a good standard of living. Most people argued that village life is very difficult — more difficult than it used to be. Another common thought, though, was that the people need to stay in the village. Rapid urban migration is creating huge strain on the cities. In turn, many cities conducted decongestion projects which involved bulldozing the shanty homes of many of the urban poor. One interviewee said,

We need to make conditions in the north [rural areas] more like they are in the city. Those people need more available to them: water, schools, clinics (fade away). Just like in the city, but we need them in the country. They should not have to suffer. ... The rural people should also benefit from the economic growth, but they do not. ... We cannot bring everyone to the city. (Gh2)

Many of the people that I interviewed were quick to discuss many technologies that could improve conditions in rural parts of the country. People in the north suffer from hard work and tedium, conditions that could be alleviated with mechanization. We talked about drilling bore-holes and rainwater harvesting, propane stoves and food processing, multi-function platforms and solar energy, and many other technologies.
Gh7: I see a very strong and critical role for engineering in poverty reduction and food security: corn grinding, cassava grating, palm oil presses. They can save a lot of time and drudgery.

JDJV: Why is it important that they can save time?

Gh7: It is important that they save time so that they have time to do other things. So they can have rest to improve their health. So they can do other activities that help them generate extra income. If a woman spends all day just processing one thing, her time is not very productive.

I enjoyed asking about the value in saving time because the traditional view of time in Africa is very different than the modern view of time. Often time consuming events are social events, and traditionally the attitude was that something was done once it was done, and that the bus left once it was full, for example. Another time when I asked about why it was bad that rural people spend so much time fetching water. The response was surprising: “It is a waste of time, and time is money” (Gh4).

The transfer of technology into a rural community is difficult, as discussed in Section 5.3, and there are many reasons projects go wrong. I was told about an irrigation project that was not used because the gods live in the water source. I heard about a latrine project that was not used because one family’s feces are not to touch another family’s feces. In other cases, people could not agree on where a bore hole should be placed, and one community was upset that another community was being favoured.

Many development projects and much effort has gone into rural areas of Ghana — mostly by foreign NGOs. Tamale, the capital of the Northern Region is considered by some to be the NGO capital of the world. “Most NGOs want to go to Tamale — that is where ‘business’ is best” (Gh14). Thousands of organizations attempt in their own way to make a difference for the poor, rural Ghanaian, but the efforts are not easy. “People in the north just don’t have good business thinking” (Gh8), complained one interviewee.
Some people talked about how outsiders cannot do much except teach the rural poor about another life: if these outsiders with their electronics and flashy clothes have the resources to travel so far, their country must be better. Other people argued that TV and the media already sell the Western way of life so much that visits from outsiders cannot do any additional harm. I often asked Ghanaians about the lifestyle in the rural areas. One interviewee told me, “if they don’t know any different, then they are happy. But now everyone is telling them about a different life, and how can we be happy when we see better opportunities?” (Gh15)

5.6.3 Engineering education in Ghana

While many of these issues are complicated, it is clear, as mentioned earlier, that there is a role for the Ghanaian engineer. The following quotation from one interviewee captures a very common sentiment: “whenever there is a development issue that needs to be addressed, the engineer has a role” (Gh8). Ghana trains hundreds of engineers a year, and these engineers are competent and capable.\(^{32}\) The challenge is to connect the engineer’s training to the needs of their people.

A big problem is that engineering in Ghana is seen as a white collar job in which one does not have to get dirty. Working with local metal workers or entrepreneurs is rarely a clean job. One mechanical engineering graduate said that three years after graduation, 42 out of 52 students of his graduating class were not working as engineers. Most of them were involved with business, banking, or other economic-related jobs. Other conversations suggested that an engineering degree was a useful way to get the authorization to leave Ghana for a high income country. An engineering professor said that the engineering students in Kumasi “know more about New York or London than they know about their own country” (Gh6). An engineering graduate student said, “Ghanaian engineers want to

\(^{32}\)I can attest to the competency of one group of students as I had the privilege of teaching a Thermodynamics course for 6 weeks.
do something useful for their country, but don’t know how. They end up working for a multinational corporation or a foreign mining company and they just end up being slaves” (Gh7).

This problem, according to one interviewee exists because engineering education in Africa was modelled after engineering education in the developed world, even though Africa’s needs are so different.

Now unfortunately for us, on this other side, the majority of our engineering has been formed in your traditions, in the traditions of the developed countries. And in my view, they have not critically transferred it here and it is not really appropriate for our environment. Because we still have very, very basic problems to solve — the majority of which don’t need half of the sophistication of things which your guys are dealing with. ... What are we dealing with here? We’re dealing with gutters and sewer systems and water that doesn’t flow and basic piping networks. We don’t need half as many Laplace transforms to solve those. ... So the formal sciences and formal education have become so very divorced from real life — much more so in our society, unfortunately, we who need it more. (Gh9)

This next quote supports that view, but also suggests that the involvement in foreign-owned industry often results in silencing the marginalized, making them further marginalized.

In Africa, and developing countries, we need universities that focus on development because the majority of us are poor. And a sizeable amount of us are marginalized and that should be of interest to us to improve on the situation. So if we fashion our curriculum so that we focus on day to day issues, it would be very good, but like I said, most universities, in our cases are fashioned after Western Universities and our curriculum is quite conservative. We need to
focus engineering on the bulk of the people and less on the needs of the elite.

It is very difficult for the marginalized to really enter the university and bring their cases across, because they don’t have the resources to support research. And most of the research is responding to the needs of industry. In most instances, the university will respond to the needs of industry because they support some of their research. So the financial issues keep the needs of the poor away. (Gh7)

Another engineering professor that I spoke to said that engineering students have no idea what they are getting into at the beginning of their program. They are good at math, and they know that engineers are highly regarded in society and well paid. When many students finish their degree, however, they do not want to just calculate, and opportunities are limited. He says that he thinks that engineering in Ghana can shake the idea that engineering is not a hands-on career. He said that engineering in Ghana must “get away from the ideas of Theory, Theory, Theory! People like to tinker and work with their hands” (Gh12). The next quote captures a similar idea:

Very few of our students would say that they came into engineering because they wanted to make things. And fewer would say so by the time they left. By the time they are leaving, they are so screwed up, they don’t think they can do anything. They think that making new things is a white magic — for the white man. ‘We don’t have much so we can’t do much.’ And I think a big challenge for us is changing engineers and showing them that they can do a lot and that there is a lot to do. (Gh9)

The next quote comes from earlier in the same interview and addresses the same issues.

JDJV: What changes would you make to your curriculum?
CHAPTER 5. RESULTS AND ANALYSIS

Gh9: For a start, I would make it a lot more practical. I would immerse it more in the industry around us, whatever state it was in. There is also much poverty around us that I would immerse it in. Now the industry around us, like Suame magazine, with all of the fitting shops and all of the welding shops and I would want to immerse some part of the curriculum in those sorts of problems of those local industrial establishments. So beefing up the practical component would be one component.

5.6.4 Implications for this thesis

Much more can be said about engineering, technology, and development in Ghana, and indeed, there is more in Appendix F. More importantly, however, it is necessary to connect the data collected in Ghana to the larger goals of this thesis. There are several important implications.

1. Data from Ghana suggests that the engineer’s role involves both technical and social components. This opinion seemed to be held unanimously, although it would, of course, be difficult to have everyone agree completely on the exact balance between time spent on the technical and the social. It was just clear that the engineer also has to be a social scientist and that the engineering education must reflect this — this is lacking in the current engineering education as suggested in the following quote.

   I think the engineer’s role is to contribute very much towards general development of society, towards progress in all spheres of social and economic life. I think that very much is the role of the engineer. I lament, myself, that we are not doing better at that here in this part of the world, than maybe you might be doing in your part of the world, maybe, I don’t know. Things seem to be working better there. But I lament the ability to

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33 A community near Kumasi with many metal workers and skilled labourers.
make a more direct impact on the social well-being of our people. So, I emphasize very much with the thrust of your thesis. It is something that I believe in very much. And I think engineers have a strong role to play and can play if we take our task seriously. (Gh9)

2. The overwhelming enthusiasm for having more Canadian engineering students in Ghana involved in engineering and development placements adds a new complexity to the role of the international placement. Why were so many Canadian interviewees quick to point to the many problems with the placement, while none of the interviewed Ghanaians were? Many interviewees in Canada pointed out that cross cultural development work must be done on the host community’s terms — what does that mean in this case? The needs in Ghana are great and complex, and perhaps their desire to be more like the West drives their desire for more Westerners ‘helping.’ Perhaps the desire to modernize and westernize is so strong that the many associated problems are not apparent. So what is the role of the outsider in light of these questions? Can international development intervention exist without ultimately making the recipients more like us? Can we genuinely help? Can we legitimately do nothing? Can Ghana ever achieve parity with the West? The needs are there, but why can they not do it themselves? That would, without doubt, be much better.

As discussed in Section 5.3, development projects can never be good or bad on their own. They could offer an important form of redistribution, but there are still many problems. But why were the problems not foreseen by the Ghanaians I spoke to? Improving the lives in the rural communities could make a large impact, for example, but what is the ruling government’s role in this? Does providing technology in this way take away from a citizen’s choice to demand good governance? These are very difficult issues and will be dealt with again in the next chapter.

3. Another important impact that the Ghanaian data have on this thesis has to do with
engineering education in Ghana. Much of what engineering students from Canada can provide could be provided by engineering students in Ghana. Engineering education in Ghana has much potential, but must be appropriately focused:

The type of engineering we do here is not problem solving for us. ... If we want to develop, we need the help of the engineer. As a people, and our cultural practises, we are having serious problems with whatever it is that we are learning at our schools — it is not solving our problems. So, to me, our engineering students should always be finding a way to see how to solve the problems of our communities. We have to solve those problems. That is what we have to do.

We are going through the school without really knowing the reason we are going through the school. We forget that we need to solve problems for our people. (Gh13)

There is less incentive for engineering schools in Ghana to address the needs of their own people when outsiders are attempting exactly that. Engineering education in Ghana must be more relevant for their people, or it becomes completely devoid of meaning. As Canadian engineering educators, perhaps we could consider how we can assist in this, but at the very least we must be aware of how our ‘helping’ may prevent this important institution in Ghana from making improvements.

4. Another important lesson in the Ghanaian data is the reminder that engineering and engineering education must be done in a cultural context. People’s thinking is very influenced by forces such as their geography, media, culture, and demographics. This is seen in many failed development projects, but also in inappropriate engineering curriculum that is modelled after curriculum in other parts of the world.
5. Another consequence of my exposure to Ghanaian thought is an opportunity to experience globalization from a different perspective. In Canada, I often do not have to think about the impact of globalized markets. Open markets have greatly influenced many industries in Canada, but my standard of living has only changed in very subtle ways. Discussing the impact of globalization with many Ghanaians reminds me of the need to challenge global markets, or at the very least not fully embrace them. I spoke with a tomato farmer who could no longer make a profit because of the low tomato prices and the great availability of foreign food. I spoke to a fisherman who said a similar thing about the prices he needs for his fish. I was told that people eat meat more often in Ghana because of globalization, but that people also struggle more to pay their bills and meet their financial requirements.

6. Section 5.4 of this thesis discusses the role of the local placement. This was not always a practical topic for interviews in Ghana, but there was, however, discussion on the importance of urban versus rural development projects. While rural placements are considered of great importance to improve the quality of life of the rural poor, there is a great need in the urban regions as well.

Ghanaian engineers are faced with much different issues when considering local needs. The dependence of the Ghanaian economy on outside forces puts the whole country in a position of subordination. Perhaps the most important thing for Ghanaian engineers to concentrate on is developing confidence and competence as they consider their own needs. Many interviewees discussed the need for the Ghanaian people, especially the engineers, to take their problems into their own hands.

I am concerned that Africa depends too much on importation and that China dominates our markets with products that are in many cases inferior. I’m concerned that we don’t have the level of skills to innovate and to explore our own local resources so that we can look internally instead of
depend on importation. I think that engineering plays a very crucial role in this regard. If we build local capacity and acquire more skills, and export indigenous resources, we will be in a better position. In a globalized world, I am quite [certain] that we are being marginalized almost every day. I think these are the things I am quite worried about and these are the things we have to worry about, as engineers. (Gh7)

Several of the interviewees discussed the value of Canadian engineering students doing local projects in Canada as opposed to internationally, but the common sentiment was that the needs are just so much greater in low income countries like Ghana. One interviewee did, however, acknowledge value in the Canadian students staying to work with locally marginalized communities:

There would be value for your students in knowing that these problems do exist inside of Canada and right next door. I think it is part of the integral education, if you like, that students don’t see a warped sense of the world, so in that view, I see value in exposing them to marginalized communities in Canada. Otherwise, I would want them to come here. They will see so much more and probably make a bigger contribution. Probably — I’m not entirely sure about that. Certainly they would see much more here than they would in Canada. (Gh9)

7. Similarly, discussions around root causes and band-aid solutions were more difficult in Ghana than they were in Canada. Several interviewees suggested that the term ‘social justice’ was either irrelevant or even pretentious. The following quote is one of the most favourable opinions expressed on the engineer’s role in working for social justice.

Engineers certainly have a role to play. Human development — yes.
Social equity or social justice — that starts to get into the political realm and even though whatever engineers do, whatever anyone does for that matter, has an impact on the politics and I hesitate to put it so categorically.

(Gh9)

Reflecting on how many Ghanaians responded to the topics of social justice, I realized that in many ways, having the time and the context to talk about social justice in Canada is a luxury. But, on the other hand, it is necessary because the luxury, in many ways, is at the expense of others who have never seen the luxury.

Again, the most important point made on this issue was the need for the Ghanaian people to take ownership of their problems. The following dialogue came shortly after the previous quote.

JDJV: Can we as engineering educators deal with some more of these political, root cause issues?

Gh9: More and more on the Africa, developing world side, we are blaming ourselves. There will always be a rich world, so if the root cause of poverty is the rich exploiting the poor, well, you aren’t going to change that. There will always be politicians and ruled people. More and more we are blaming ourselves because we think it is our attitude that is keeping us poor people, keeping us as underdeveloped societies and therefore we have to find ways of changing our attitudes. ...

Those of us in this school of thought tend to think that the politics is a reflection or a symptom of the base attitudes of the people. If you have people whose base attitude towards authority is one of reverence, then politicians will continue to exploit them. So, what am I going to do about the politics, really, as far as engineering is concerned? As far as anything is concerned, let alone engineering. I would focus engineers on getting a
more ‘can do’ spirit. A more interventionist attitude as far as social atti-
tudes around them are concerned and hopefully that will translate into the
politics and economics around them.

In the end, it is hard to articulate all of the lessons learned as I tried to address my re-
search question in Ghana. The most important lesson, however, revolves around the chal-
lenge of crossing a border with the intention to help. My gut reactions in Ghana typically
made me believe less in the role of intervention. But I also learned to find some impor-
tant shades of grey on the issue. History cannot be changed and indigenous knowledge
has been lost, and the foreign resource extraction companies will continue to exploit, and
young people will continue to sell the Western ways during their altourism\textsuperscript{34} expeditions.

In my interviewing, I came across two stories that especially encouraged me. First, one
African student talked about a time he was exposed to a teacher from America. He talked
about how encouraging it was to see that the American was very human and fallible.
That experience caused him to know that Africans can be equally capable. He said that
“through the white teacher, I saw that we are all the same. She was not worlds above”
(Gh11). This is a critical lesson on a continent that often has a inferiority complex when it
comes to racial issues.

Another story is from an engineer who saw an American engineer working hard with
poor Ghanaian people. He came to realize that if a foreigner was not too proud to get dirty
and help the people, then he should definitely not be too proud to work to help his own
people. He said, “Hard work is a nice example — If the white man is willing to work hard
for our poor then we should too” (Gh15).

I believe, like in so many human interactions, it comes down to attitude and humility.
One interviewee claimed that we all have to be optimistic when it comes to these issues.
He said,

\textsuperscript{34}A term coined by Sichel to combine altruism and tourism [194].
The route is full of trouble, but you’ve got to try to do something. The pessimist says, ‘Don’t do anything.’ Dealing with our problems is part of being human. We will try to find a solution to deal with the problems. (Gh6)
Chapter 6

Further discussion

It is easy to write about what ought to be. The hard question is how, in the real, messy, corrupting world to encourage and enable more people to move in these directions; how to multiply the numbers of committed outsiders ... who see the need to put the last first, and how to stiffen their courage and will to act. – Robert Chambers

Go to the people. Live among them. Learn from them. Love them. Start with what you know. Build on what they have. But of the best leaders when their task is done, the people will remark, ‘We have done it ourselves.’ – Chinese poem

I shall always remember how often I was humbled by those illiterate herdsmen who possessed, in so much greater measure than I, generosity and courage, endurance, patience and light-hearted gallantry. Among no people have I ever felt the same sense of personal inferiority. – Wilfred Thesiger

Navigating this world and making meaningful decisions that improve relationships is challenging for almost all people in this industrialized world, including the engineer. In an
age that is dominated by global politics and obsessions with the next quarter’s growth, it is
difficult to think long term, and beyond economic measures. The planet is in an unprece-
dented state of imbalance, and engineers are critical to address the global challenges. Not
only has the engineering profession been at the forefront of the rapid resource extraction,
industrialization, manufacturing, and globalized transportation and communication, but
engineers with their systems approach, technical knowledge, and problem solving skills
are in a strong position to play a role in the creation of more nourishing and sustainable
communities. It is hard for the average engineering student to see how engineering has
anything to do with marginalized communities and even harder to work for a positive
change. This chapter addresses this impasse from an engineering curriculum standpoint.

The previous chapter presented and organized the ideas from the research interviews
and fieldnotes. The data was structured into 5 distinct concepts, each with its own pool of
understanding and outcome space. Before moving to some conclusions and recommendations, there is a need to discuss the data further. The following discussion and analysis is
based on the hierarchies developed in the previous chapter and my reflections during the
past years of this transformative\(^1\) research.

With phenomenographic research I cannot make objective conclusions about a physi-
cal truth, but I can make some informed suggestions based on the outcome spaces. The
discussion included in this chapter addresses the research questions by looking at these
outcome spaces. When ideas are taken from the outcome spaces in Chapter 5, the section
number appears in square brackets after the thought. Table 6.1, which lists the categories
found in the data, is a useful tool for cross-referencing the category with the section num-
ber.

So, how does the data from the previous chapter help us answer the research question?
What does it say about the needs, opportunities, benefits, and limitations of a potential

\(^{1}\text{On a personal note, my opinions and ideas have substantially changed during the course of the project. At the}
\text{beginning of this research, I saw international engineering development projects as inherently good, and did not really consider local projects or working for root causes. This research has truly been transformative.}
<table>
<thead>
<tr>
<th>Concept 1</th>
<th>The social role of engineers</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1.1</td>
<td>No social responsibility</td>
</tr>
<tr>
<td>5.1.2</td>
<td>Responsibility for public good</td>
</tr>
<tr>
<td>5.1.3</td>
<td>Engineers improve society through technology</td>
</tr>
<tr>
<td>5.1.4</td>
<td>Social improvement through broadening perspectives</td>
</tr>
<tr>
<td>5.1.5</td>
<td>Engineering work requires understanding of social location</td>
</tr>
<tr>
<td>Concept 2</td>
<td>Humanitarian engineering as a part of the engineering curriculum</td>
</tr>
<tr>
<td>5.2.1</td>
<td>A good idea for those who are interested</td>
</tr>
<tr>
<td>5.2.2</td>
<td>Something to which all students should be exposed</td>
</tr>
<tr>
<td>5.2.3</td>
<td>A useful step towards broadening the curriculum</td>
</tr>
<tr>
<td>5.2.4</td>
<td>All curriculum should be built around social impact and community</td>
</tr>
<tr>
<td>5.2.5</td>
<td>Some unlearning is necessary before this can be effective</td>
</tr>
<tr>
<td>Concept 3</td>
<td>An international, humanitarian engineering placement</td>
</tr>
<tr>
<td>5.3.1</td>
<td>Placement is inherently good</td>
</tr>
<tr>
<td>5.3.2</td>
<td>Placement requires careful training</td>
</tr>
<tr>
<td>5.3.3</td>
<td>There is a lot of potential for harm, but placement can work</td>
</tr>
<tr>
<td>5.3.4</td>
<td>Placement is most valuable for student learning</td>
</tr>
<tr>
<td>5.3.5</td>
<td>The learning experience comes at a great cost</td>
</tr>
<tr>
<td>5.3.6</td>
<td>Placement must be about social justice</td>
</tr>
<tr>
<td>Concept 4</td>
<td>A local humanitarian engineering placement</td>
</tr>
<tr>
<td>5.4.1</td>
<td>Local engineering and development projects are impossible</td>
</tr>
<tr>
<td>5.4.2</td>
<td>Local projects are possible, but with significant obstacles</td>
</tr>
<tr>
<td>5.4.3</td>
<td>Local placements are possible and important because of the need</td>
</tr>
<tr>
<td>5.4.4</td>
<td>If there are to be placements, there must be a local component</td>
</tr>
<tr>
<td>Concept 5</td>
<td>Engineering to address the root cause of marginalization</td>
</tr>
<tr>
<td>5.5.1</td>
<td>Technology cannot address the root causes</td>
</tr>
<tr>
<td>5.5.2</td>
<td>Engineers can only address the symptoms, but still have social merit</td>
</tr>
<tr>
<td>5.5.3</td>
<td>Humanitarian engineering can address root causes, starting with discussion</td>
</tr>
<tr>
<td>5.5.4</td>
<td>Humanitarian engineering must address root causes</td>
</tr>
</tbody>
</table>

Table 6.1: A summary of the categories found in the data
humanitarian engineering program and the subsequent role of the engineer? What does it say about potential ramifications to the engineering curriculum? This section answers these questions.

6.1 The need

Is there a need for a humanitarian engineering program for engineering students in Canada?

Before answering this question, it is useful to step back and consider what one of my interviewees asked me after our interview: Why do we need formal engineering education at all? Immediate answers include our need for products and infrastructure, for transportation and communication, for water and sanitation. But the history of engineering shows us that many of these things were developed long before engineering was taught at the universities. As mentioned in Chapter 3, modern engineering education began in France with the demand for rapid military development and in England and the USA with the demand for rapid industrialization. Engineering today continues to be used for creating more deadly weapons, more efficient industrialization, and a vast array of more frivolous consumer goods, and thus it is necessary to consider this question from a human perspective. Why do we need to train engineers if the goal is, in fact, stronger communities and relationships? The answer is that the engineer can be (and has been) a useful person in a community. Anyone who has a good understanding of the physical world and can use that understanding to create useful tools and processes has value to a community. To be convinced, one just has to imagine designing and setting up a shelter without someone with the proper skills to do so. Whether or not the university is the correct place to develop the necessary skills is another question, and outside of the scope of this project. However, it is logical to say that while we cannot change the fact that students are going to attend university to train to be engineers, we can train these students to think more about human need and marginalization.
Chapter 6. Further Discussion

Need is a challenging word to discuss. Need, used as a noun, implies either something necessary for survival, or something required to address a problem, but it is often difficult to differentiate from something that is merely wanted. The word ‘need’ is highly subjective, unless used in conjunction with a sense of absolutely necessity for survival.

A humanitarian engineering program can potentially address a number of problems, but it would be difficult to argue that it would be essential for anyone’s survival. While there are many humans in great need, I cannot conclude that a humanitarian engineering program is required for them to remain alive. Therefore, we cannot be objective, and it is necessary to look back at the data in the previous chapter to answer this question. Because of the subjective nature of this research, my biases and perspectives cannot be separated from the conclusions, but I can illuminate a useful point of view, revealed by the data from the lived experiences of the interviewees.

In considering the need for a humanitarian engineering program, both the university and the community must be considered. Also, using the definition of humanitarian engineering and human development from Chapter 1, it is clear that the question of ‘need’ can only be answered by considering both the local and global communities.

Looking at our own local communities, it is clear that there is no shortage of marginalization. There are still significant ‘us and them’ attitudes towards the disabled, homeless, and poor. The dialogue brought up in Concept 4 (A local humanitarian engineering placement) suggests that engineering can and should address the issues of marginalization [5.4.3]. The highest level of the hierarchy suggests that, as citizens, we must be engaged in our own community; as engineers, we need to use our skills to contribute locally. Esteva argues against the growing trend to focus on global issues and far-away injustices and suggests that “what is needed is people thinking and acting locally, while forging solidarity with other local forces that share this opposition to the ... ‘global forces’ threatening local spaces” [64]. Local work can focus on engineering intervention in acts of charity, but must attempt to address, through activism, for example, the root causes of the marginalization.
Thinking about addressing root causes as an engineer may require a broader perspective of engineering\(^2\) as discussed in Concept 5 (Root causes of marginalization) [5.5.4].

There is much research about the state of the world and human need; it will not be difficult to convince anyone that the extent of human need is great. The poorest people remain the most vulnerable;\(^3\) and the rules created by those in power are often designed to protect the interests of the wealthy, powerful, and ruling elite. The engineer, often at service to the ruling elite, also has skills in providing for basic human needs. If technology and engineering can be useful, then engineering students should be trained to see their potential to bridge the entrenched gap between power and powerlessness. Concept 3 (An international humanitarian engineering placement) acknowledges that engineers and their appropriate technologies can be useful, but must also be thoughtful about the many dangers associated with applying technology cross-culturally [5.3.5].

Applying engineering work to help the marginalized both locally and internationally can be useful. In fact, they complement each other. According to Concept 4, local work must happen first; only then can international work be carefully considered [5.4.4].

Thus, there is an opportunity to work at the community level (locally or internationally) as an engineer. If we wish to work for social equality and justice, the chance to do so exists. Humanitarian engineering can be used to combat the problem of injustice and inequality and therefore, there is a need for a humanitarian engineering program.

It is useful to look at this research question from the perspective of the university as an institution. Engineering education, like all education, is a dynamic entity and varies through time and location. In our current cultural climate, the university is pressed to emulate a business more than ever before: the graduate is the product and the other institutions, even institutions on the other side of the planet, are seen as competition.\(^4\) In a time

\(^2\)It is acknowledged that there is a need to discuss more specifics. This will be done in Section 6.6: Implementation.

\(^3\)A paper entitled, ‘Growth is Failing the Poor,’ cites that 96% of the people who die from natural disasters come from low income countries [195], for example.

\(^4\)See the article called the Brain Business [92].
when many engineering faculties are struggling with declining applicant pools, decreasing percentages of female and minority students, and tighter budgets, a new program that would attract students, especially females and minorities, should be very appealing. All indicators suggest that Humanitarian Engineering would address these enrollment concerns without sacrificing the competency of the engineer or the competitiveness of the institution [27, 151].

While the argument above may be the most convincing one to institute a Humanitarian Engineering program, and while the health of Canada’s higher learning establishments is an issue of some concern, changes to engineering education must be considered from a more universal point of view. A university must not just be for the benefit of a small percentage of the world’s population, but must be for increased awareness of social location which in turn will influence many, according to Concept 1 (The responsibility of engineers) [5.1.5]. Engineering education has always been focused on skills training for productive workers, but it is essential that engineers are also taught critical thinking. Concept 2 (Engineering curriculum) indicates that engineers, through their education, need a broader perspective and a greater understanding of their interconnectedness [5.2.4]. From this perspective, it can also be seen that there *is* a need for a humanitarian engineering program.

Some people argue that since they cannot change the course of the world, there is little point in trying. There are two necessary responses to this belief. First of all, the goals of humanitarian engineering cannot practically be to end suffering or poverty, but to work for greater social justice and equity. We are easily paralyzed by the challenges of the big picture. While there will always be greed, and all of us will advance our cause at the expense of the weak around us, the point is to be aware of these forces and to work against them. Secondly, our job is not to save the world — that is too monumental — our job is to be a responsible profession, acting with integrity. Strengthening individuals or communities is more manageable.  

5Several sources of ancient wisdom suggest that saving an individual is just as important as saving the
A final point: the bulk of the argument thus far has been on a moral or ethical ground. It is worthwhile, as an aside, to briefly present a similar argument from a different perspective. Some people think that moral and ethical arguments are too easily ignored in a pluralistic, market driven society. Ivan Head, a former president of the International Development Research Centre (IDRC) and former foreign policy advisor to Prime Minister Trudeau, for example, argues that all nations suffer from the erosion of the economic welfare, social harmony, political stability, and environmental well-being that the South currently experiences. He says that the scourge of poverty breeds discord and the North is not immune to it [196]. Muhammad Yunus agrees, saying that “Poverty is a threat to peace.”

Table 6.2 gives a summary of the arguments in favour of a humanitarian engineering program.

<table>
<thead>
<tr>
<th>Locally</th>
<th>We must be engaged in our own communities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Globally</td>
<td>The needs are great and engineering can help</td>
</tr>
<tr>
<td></td>
<td>Appropriate technology can alleviate hardship</td>
</tr>
<tr>
<td>University</td>
<td>Attract quality students, improve enrollment</td>
</tr>
<tr>
<td>On the whole</td>
<td>Broader, more aware of interconnectedness</td>
</tr>
<tr>
<td></td>
<td>Harmony, stability, and environmental well-being</td>
</tr>
<tr>
<td></td>
<td>Marginalization leads to discord, threatens peace</td>
</tr>
</tbody>
</table>

Table 6.2: There is a need for humanitarian engineering curriculum

6.2 The opportunity

Is there an opportunity for a Canadian university to offer a humanitarian engineering program? In many ways, discussing opportunity is the same as discussing need; if there is entire nation. Surah Al Ma’ida’ (5:32) of the Qur’an, for example, states that “If anyone saved a life, It would be as if he saved the life of the whole people.”
a need, there should be an opportunity. There is a difference, however: the word ‘oppor-
tunity’ has a more practical component. Perhaps a clearer question is, are the conditions
currently in place for a humanitarian engineering program to work?

First of all, is there political will for the university to undertake a program like this?
Certainly the educational component of a humanitarian engineering placement is beneci-
ial and consistent with the university’s mandate, as discussed in Category 4 of Concept 3
(An international humanitarian engineering placement) [5.3.4]. But, as discussed in Cate-
gory 5, the learning experience is not without its costs [5.3.5]. The political will to overcome
these costs, financial and otherwise, is tested by how the university views it role in pro-
viding benefits for outsiders, especially when the benefits are primarily for marginalized
communities, both internationally and locally.

How does the university view its role with the community, at home and abroad? In a
sense, this question is irrelevant. There is a need and one of the university’s primary pur-
poses is to serve the larger community. This is explicit in Queen’s University’s statement of
purpose [197] and in the principal’s essay, ‘Engaging the World’ [198], for example. Ursula
Franklin says that “the purpose of a university is not only to be a place where knowl-
edge and understanding find a home, but also to provide a bridge for interaction with the
larger community” [10]. If a humanitarian engineering program can be shown to benefit
local and global communities, then can we not conclude that there should be a place for
it in the curriculum? However, a university needs to be concerned with enrollment, fund-
ning and budgets and unfortunately, in a capitalistic society, policy changes are often more
influenced by money than relationship. For this sort of undertaking to exist within the
university institution, it must make financial sense.

New academic programs come with a price tag. Costs can be high, and in the case of
a humanitarian engineering program with an international placement, the travel expenses
add up. It does appear, however, that there is an opportunity for fund-raising for this
sort of project. Queen’s University, for example, has engineering alumni who have been
successful in the profession and want an opportunity to give back to a community in need. A preliminary fund-raising endeavour showed that several potential donors are willing to contribute, in large part because Humanitarian Engineering is perceived to (and strives to) promote the greater social good.

While it is easy to understand that the university will accept the charity model of humanitarian engineering along with student placements and appropriate technology, it is more difficult to see the benefits in addressing further critical thinking. Is there political will to make the engineering curriculum more critical? Critical analysis does not necessarily create jobs or economic growth, tasks in which those who fund the university are extremely interested. Consider Rockefeller’s statement: ‘I don’t want a nation of thinkers, I want a nation of workers.’ The model of engineering education described in Concept 2 (Changes to the engineering curriculum) requires a certain conceptual framework where some ‘unlearning’ needs to happen [5.2.5]. The opportunity for this conceptual framework may not be completely available, but the university is still designed as a haven for free thought, and with the appeal of humanitarian engineering perhaps enough to get a program started, enlightened faculty members can do their best to move the program further along the social justice/charity spectrum. This is perhaps the largest challenge in properly shaping a humanitarian engineering program [5.5.4].

Smillie echoes these ideas by suggesting that a ‘lack of political will’ should not result in an excuse to stop fighting marginalization, but in a desire to better understand and work against the forces of impoverishment.

Poverty has reached such an unacceptable world level, not because the world has no tools to deal with it, not because we are short of ideas, but because we are short of the political will to use the tools properly and to implement the ideas effectively. ‘Lack of political will,’ however, is a convenient term for summing up the shortcomings of others. It usually means that the
rich and powerful are acting in their own best interests, but it is a catch-phrase
that stops short of discussing how those interests — local and international —
capture and distort international development efforts. [2]

There is some concern about career opportunities after graduation from a humanitarian
engineering program. Students and faculty alike may argue that humanitarian engineer-
ing is extraneous to ‘real’ engineering, as seen in Category 3 of Concept 2 (Changes to
the engineering curriculum) [5.2.3]. In this view, humanitarian engineering is a program
which gives the students an opportunity to do good, to go on a placement and have an ex-
citing, educational, cultural experience. These students are then concerned about having
the right skills to return to a ‘normal’ engineering job.

First of all, this attitude does not mesh with the model of humanitarian engineering
explored in this thesis. Humanitarian engineering must be presented as a philosophy that
governs how all engineering education is taught [5.2.2]. If a university has a humanitarian
engineering program, the students will still learn all of the fundamental technical skills;
their education will just contain more social impact built into design courses and more
human need built into analysis courses. Students who decide to focus their engineering
education on marginalized communities and perhaps participate in a placement will still
be trained to be competent engineers, but will have a slightly different specialization, just
like some engineers are more literate in thermal/fluid systems and others are more com-
fortable with automatic control engineering.

Secondly, students who do take on a humanitarian engineering placement, be it lo-
cal or international, will benefit from the practical experience working as an engineer in
a marginalized community. As mentioned in Concept 3 (An international humanitarian
engineering placement), these cross-cultural experiences require and enhance both strong
engineering and strong leadership skills [5.3.1]. This will make the engineers more em-
ployable after graduation. The following conversation captures this:
Ca8: You can learn so much from just immersing yourself in a different culture and a different country. Even the work itself is probably going to be miles away from what you are used to doing at school and on paper. You’re dealing with people, you’re managing a project, you’re writing reports and trying to communicate problems and strategies on how to overcome things and you can gain so much from that. I think that will be really valuable for engineers who tend to have a lot of the hard skills but not a big emphasis on the soft skills and things that matter. And even if you decide never to do development work again, I think that those are some real valuable professional skills to have.

... 

JDJV: How has engineering and development work that you’ve done helped with your career? Has it made you a better engineer?

Ca8: That’s a tough question. It is funny to think that I was overseas not so long ago and now I’m working with people who are not necessarily that concerned about the world’s problems. I think that it definitely helped me. It hasn’t really changed how I run through my calculations and do that sort of stuff, but I think it has helped me get in front of a crowd. It is really great immersion. The other thing that is really neat too: before this all of my experience was in school and in school you are learning, but as soon as you go into a developing country you are an expert or people consider you an ‘expert’ and people care about what you have to say. There is a bit of a transition in your mindset where people are listening to you so you better give a good answer. You can just as easily spread misinformation as good information. I think that in consulting that is also another good little thing to remember in your everyday work. We are often looked at for answers to things.
Industry and developmental agencies alike want students with humanitarian engineering skills because of their strong engineering and leadership abilities, but also because of their ability to address the social impacts of their design. As discussed in the paper Peace Engineering [135], there are opportunities for engineers to work for development agencies — governmental or non-governmental, multilateral or unilateral. A humanitarian engineering program can prepare students to work in these organizations.

When humanitarian engineering is taught as an underlying philosophy, the student has to address a range of moral and ethical choices when seeking future employment. An important part of humanitarian engineering is teaching how to find solutions to inequity and injustice (Concept 5: Treating the root cause) [5.5.4], and corporations which hire engineering graduates can be amongst the most exploitive. Perhaps a humanitarian engineering program will help students better understand how individual corporations fit in with our social location. A major goal of humanitarian engineering is not just to create an opportunity to send students on an adventure to be a poverty tourist, but to foster a desire for lifelong interest in making lasting change [5.3.6]. It could result in engineers with a greater social conscience, able to question designs with planned obsolescence or to seek fairness when minerals are mined from aboriginal land, if they are to be mined at all. Students who go overseas and return will, it is hoped, continue to invest in working cross-culturally to create positive change in local, marginalized communities. The employment opportunities may be fewer and less remunerative, but seeing beyond the glossy Corporate Social Responsibility (CSR) brochures will be more satisfying [5.5.4]. In the end, everyone has to do something meaningful with their time, and while a greater social conscience may limit some career opportunities, it can also make available other rewarding possibilities.

So, in answering this part of the research question, there is not the same resounding ‘yes’, but there is still enough evidence to say that there is an opportunity for a humanitarian engineering placement based on considering both the university and the student.
Table 6.3 gives a summary of the points suggesting that there is an opportunity for a humanitarian engineering program.

<table>
<thead>
<tr>
<th>Political Will?</th>
<th>Beneficial educational component</th>
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<tr>
<td></td>
<td>University should support community</td>
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<td></td>
<td>Attractive to donors</td>
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<td></td>
<td>Additional skills for graduates</td>
</tr>
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<td></td>
<td>Additional employment opportunities</td>
</tr>
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</table>

Table 6.3: There is an opportunity for a humanitarian engineering program

### 6.3 The benefits

What would be the **benefits** of having a humanitarian engineering program?

Several benefits have been discussed in the data, but the most tangible one is the educational enhancement for the students. A curriculum with humanitarian, social justice, and critical analysis components will provide a rich educational experience, according to Concept 2 (Changes to the engineering curriculum) [5.2.3]. In addition, the opportunity for a local or international placement will provide a valuable broadening experience [5.3.4, 5.4.3]. These educational elements have the potential to create responsible citizens who live with both their heads and their hearts. A humanitarian engineering program will not automatically transform the world but, if implemented thoughtfully, can be essential in creating balanced people who experience visible personal growth during their engineering education, which fits well with accreditation goals [99, 110].

In an ideal world, this educational experience for the individual would, in turn, result in a more visible role for engineering in building stronger communities. Local and international impoverished communities could be strengthened, and even the relationship between a university and its surrounding community and within the engineering classroom could be improved [5.4.4]. But the world does not readily favour the ideal, however,
and it is not possible to predict exactly what changes could be expected. But it is not naive to imagine that more thoughtful graduates could infuse a sense of mercy, justice, and humility into their communities. One interviewee said the following:

With this kind of course, we can promote working for the poor, and those students, when they graduate, I think, there is more chance volunteering to do something like that. That student will come back to tell his story and create awareness and live a changed life. (Ca9)

It is easier to argue that this curriculum change will make for a stronger university. Enrollment opportunities, interdisciplinary dialogue [5.2.3], and improved relationships with the community are immediate advantages that come to mind. Queen’s University has recently established a vision of ‘Engaging the World’, and a humanitarian engineering program would attempt to do this in a positive manner, while stressing the importance of engaging Kingston at the same time.

Finally, the entire engineering community will see the benefits of humanitarian engineering. The potential benefits could include an improved perception of the role of engineers in society, more socially sensitive engineers, and the fostering of an environment for appropriate engineering conversation [5.1.4]. Table 6.4 lists the benefits given in the previous paragraphs.

Can relatively simple curriculum changes deliver such an impressive list of benefits? Yes and no. The list above is definitely idealistic, but it really is an issue of attitude. The forces of increased production, growth, wealth accumulation, and greed are strong and pull in the opposite direction in many cases. But if building community and fighting marginalization and oppression starts with a desire for love, justice, and humility, engineers must be encouraged and trained to see their profession as a means to good ends.
Excellent educational experience
- deeper understanding of social location
- cross-cultural sensitivity

Stronger community
- commonality with marginalized
- work for justice and equality
- improved relationship between community and university

More thoughtful and sensitive graduates

Stronger university
- engineering enrollment
- interdisciplinary dialogue and multidisciplinary projects
- Engage the World and Engage Kingston

Perceived role of engineers in society
- more socially aware engineers

| Table 6.4: Some benefits of humanitarian engineering |

6.4 The limitations

What would be the limitations to what a humanitarian engineering program could offer?

The list of benefits is impressive, but even good intentions, if not well thought out, can do more harm than good. A humanitarian engineering program carries definite limitations, and even liabilities. In the following quote, Robert Chambers alludes to the liability of development, saying

That sometimes growth and modernization make the poor poorer; that the main gain from increased agricultural production often goes to urban populations and rural rich; and that the better off and more powerful benefit more from rural services than do the poor and weak. [56]

The following section lists some of the limitations and liabilities that came up in the research interviews and fieldnotes. The limitations and liabilities come from all 5 phenomena, although Concept 3 (An international humanitarian engineering placement) provides
the largest number of concerns because of the great challenges connected with international placements. One is quick to see that the list of limitations is longer than the list of benefits. This should be taken as warning to all involved with setting up this type of curriculum, or perhaps it has something to do with the Second Law of Thermodynamics: it is much easier to mess things up than to set things right.

The limitations and liabilities of a humanitarian engineering curriculum:

- **Cost of the program.** The strength and effectiveness of a humanitarian engineering program will depend, in part, on the available finances, although even with a single part-time employee, a significant impact could be made. That being said, having placements, guest lecturers, and course development all comes at a certain expense [5.3.5], and the amount of money available will influence the strength of the program. The available money will, of course, be finite, and thus the program will be limited by its budget — especially if it is desired to send as many students as possible on placements.

The money that would be spent is not insignificant and it would be healthy to continuously ask if the money could be spent more effectively.

- **Inappropriate balance between technical and social material.** A very serious liability could occur if a Humanitarian Engineering program has too strong a focus on the social issues and neglects the technical issues [5.2.3]. The two must be carefully balanced; otherwise the humanitarian engineering curriculum might not be taken seriously or the quality of the education could be compromised. However, as will be discussed in Section 6.6.1, competency is not a direct result of the amount of technical information absorbed by the engineering student.

It is necessary to stress that technology for human need and lower-tech solutions, like wood burning cook-stoves, by no means mean simple or compromised science. There is plenty of opportunity for challenging research and engineering work in
projects for human need, as will be discussed in Section 6.5, under the *A Problem Solver* subsection.

- **Too much focus on technology as a solution.** This next liability will be discussed in Section 6.5, under the *A Problem Solver* subsection, but is worth a brief mention here. Engineers are trained to be technical problem solvers and thus they tend to try solve every problem with technology when other approaches might be more appropriate [5.2.5]. A program that teaches engineers to use their skills to meet human needs, would be ineffective and possibly damaging if young engineers in turn try to force technology solutions to solve social problems. Instead, engineering students need a broad education so they can understand their role in multidisciplinary settings.

- **Cross-cultural social structures are not understood.** The data included many warnings and anecdotes about cross-cultural engineering projects that went awry because of a lack of understanding social structures [5.3.5]. For example, one of my Ghanaian interviewees described a latrine project in Northern Ghana, in a community that suffered from high rates of waterborne diseases, including dysentery. Beautiful latrines were built, but never used because the engineers, despite attempts to understand the culture, never learned that the feces of one family were not supposed to touch the feces of another family. (Even spouses were considered to be from different families.) Talking about feces is considered taboo in this specific community, and it took over 2 years to completely understand why the latrines were not being used.

  This and other stories that were relayed to me demonstrate the extreme difficulty in applying technology cross-culturally. Cross-cultural communication is difficult, and sometimes impossible, to teach. Perhaps this is why, from time to time, I would be asked, ‘Do we really need more engineers in development?’

- **A creation of dependency.** Continuing on with some of the limitations and liabilities
of cross-cultural placements, aid work can create a climate of dependency [5.3.5]. Humanitarian engineers can develop wonderful, culturally sensitive designs, but these designs will disempower the community if they create long term dependency on an outside technology, as discussed by many post-colonial thinkers.

While in Ghana, I was able to travel to a rural community of 30,000 people that had its water treatment and pumping facility burn down. The fire had taken place over 6 months prior to the visit from the development team that I accompanied. The community did not know how to recover from the disaster and proceeded to get their water from a stagnant pool nearby, in an area where Guinea Worm was still prevalent. The community waited for the next NGO visit to fix their water supply. The dependency on outside help struck me most when I learned more about the once mighty Ashante kingdom that occupied the same land several hundred years earlier. The Ashante kingdom controlled an empire that traded with people throughout Africa and eastern Asia and had a great deal of influence. It was sad to see people with such a proud past, waiting for the vital assistance while their children suffered from low quality water.

Money is a common source of imbalanced relationships; the receiver will often be at the mercy of the donor. NGOs work to meet the expectations of their donors, even if it means not drilling in the area that water is most needed (to ensure that they hit water), and aid often requires its recipients to adjust other cultural practices to conform with advice from the giver. Donations can cause more harm than good. This creation of dependency is most likely to occur when the development project is carried out with the thinking that the outsider knows what is best for the community.

- **Undermines people’s ability to care for themselves.** A related limitation is that service work can undermine a community’s ability to care for itself or demand good governance [5.3.5]. People have a strong drive to survive and to meet their family’s
needs. It is patronizing to think that an outsider can enter a community and know what is best. The following quotation captures this ideal well.

People who live in privation develop those haywire, stop-gap solutions. If all you have is duct tape, then you learn to fix whatever it is with duct tape. Or, if all you have is rubber hose, you learn to fix whatever it is with rubber hose. If all you have is mud, you learn how to build stuff and fix stuff out of mud. So just because you have training in engineering doesn’t mean you are going to be better to help people fix the machines or the infrastructure they are dealing with in a way that is more sophisticated than what they are already doing. (Ca1)

There will always be times when people need assistance, but there can be danger when it is not given on their terms.

• **Adjusting cultural practices via external influence.** Another concern about a humanitarian engineering program is that cross-cultural placements can lead to unnatural adjustments in cultural practice [5.3.5]. Few would argue that culture must be static and unchanging, but cultural adjustments should be primarily instigated by the community itself.

There is much good that can be said about a corn dehusking machine, for example. It can reduce physical labour and increase available income. However, it may also disrupt the social system. Again, one Ghanaian interviewee told a story about how a corn dehusker that was introduced into a rural community eliminated a social event where the women of the community met to dehusk corn. The new machine was too noisy for conversation and worked best as a one person job. There was more time and money, but the community was not necessarily happier.

This point again stresses the connection between technology and society and the fact
that technology is not neutral. Ursula Franklin writes extensively about this exact topic. She says that computer donation to low income areas is not unlike using Bibles for teaching literacy [10]. She is making the point that underlying much development work is the attitude that we want to make them more like us. We can, however, be certain that our planet does not need more people living the typical western lifestyle.

• **Technology transfer is extremely difficult.** This next point was originally made in Concept 3 (An international humanitarian engineering placement) [5.3.5] and will be discussed again in Section 6.5, under the *A Problem Solver* subsection, but it also belongs in this list. Technology is a cultural entity, meaning that it will work best in the community that developed it. The mostly unused Roman baths that have been found in England suggest this exact point. For technology developed in one culture to work in another, successful technology transfer must occur. For this to happen, however, the receiving group must learn to think more like the technology developers. This is not impossible (or necessarily desirable), but there are great risks of creating dependency and disempowerment, as discussed earlier.

• **Unnatural power relationships.** Outsiders often represent an exotic, wealthy and capable far away land. When engineering students come from a wealthy part of Canada to an impoverished, low-income community, they are given high social status and esteem because they are perceived to be extremely powerful [5.3.6]. I was told a story in Ghana about a second year engineering student from Canada who was put in charge of a practising Ghanaian engineer during the student’s engineering/development placement. Several interviewees had similar experiences.

  * [When I’m in Kenya,] I see a lot of people from the West, trotting around feeling good about themselves because they are so highly respected and people assume that they are experts in everything. And it feels good, but it’s not based on reality. (Ca16)  

These unequal power relationships can be demotivational and create inferiority complexes for the local people.

- **The placements only have charity aspects.** Another limitation is that the engineering connection to community work will only have charity aspects. Charitable work is useful and important, but it will never challenge the status quo and remove the sources of oppression, as discussed in Concept 5 (Treating the root cause) [5.5.4]. This becomes a liability when enthusiastic youth who are excited about having a positive impact for change become cynical and burned out. One of the interviewees asked the following question:

  Lots of people want to have a positive impact, but are they willing to be radical enough to be a force of change? (Ca12)

The students will have to be encouraged to accept the difficulties of involvement, and go beyond the charity model, as difficult as that can be. If this is not done, the program will not reach its full potential of seeking solutions to root causes of disadvantaged communities.

  If we [educators] fail to invest in the collective goods of community, social capital, and diversity, ... then we socialize our students to accept statuses in institutions that generate inequalities unjustly and reinforce cultural beliefs regarding the immutability of such problems. [158]

- **Embraces globalization.** There is much dialogue in the engineering education literature that suggests that international placements are useful for preparing engineers for working in a global context. This may be true, and the internationalization of the work force is undeniable, but this sort of dialogue takes away from the necessary critical analysis of globalization. Joseph Stiglitz, a former Chief Economist of the
World Bank and author of \textit{Globalization and Its Discontents}, argues that free-market economics and globalization do very little to help the marginalized \cite{45}. The place of engineering in globalization must be analyzed and better understood \cite{5.1.4}. While cross-cultural experiences and the development of multicultural skills are excellent outcomes from an international experience, it is essential that these are not obtained at the expense of a critical examination of globalization, in which the distribution of the benefits and costs of globalization are discussed. Johnson says,

There has been a worrying tendency for the global reach and impact of engineering to be based essentially on North American or European perspectives. We need to reclaim the term globalization as implying the celebration of rich diversity, not as a recipe for an essentially neo-colonial domination by a perspective drawn from one or two regions, however powerful they may be. \cite{80}

- **Program success is dependent on attitudes of administrators.** Just as the personal success of a humanitarian engineering placement depends largely on the attitude of the placementee, so the overall success of the program will depend on the attitude of the administrators. Institutional leaders must look beyond improved public relations and the humanitarian engineering program will require a team to move it in the right direction. For many of the reasons discussed earlier, the program should appeal to the university administration and the students, but it will also be very easy for the university to benefit without the curriculum really focusing on the needs \cite{5.5.4}. One interviewee said the following about this:

  Humanitarianism is being used as a public relations campaign. As much as I love to do it, it is in large part a way of servicing our large burden of guilt that we feel because of our privilege. And it is a way of
serving our guilt instead of serving our desire to build good life for all.

There is something innately self-serving. It can blind you. (Ca10)

- **Program tries to be too ambitious.** Sometimes, if change is brought on too quickly, it is resisted. A humanitarian engineering initiative cannot be too enthusiastic, but must be willing to slowly make the necessary, incremental changes in the engineering curriculum. [5.1.4] This is analogous with creating change in a community by introducing new technology, for example. This sort of change must be made with great consideration and thought. In general, appropriate technology will be small deviations from the status quo. As Schumacher observed, small changes are comparable to stretching but large changes cause rupture [38].

Table 6.5 summarizes the potential limitations of a possible humanitarian engineering program.

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<thead>
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<tbody>
<tr>
<td><strong>High cost of the program</strong></td>
<td>There could easily be an inappropriate balance in the curriculum</td>
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<td></td>
<td>- between technical and social material</td>
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<tr>
<td></td>
<td>- too much focus on technology as a solution</td>
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<tr>
<td>Cross-cultural placement are difficult and can be patronizing</td>
<td>- social structures are not understood</td>
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<td></td>
<td>- creation of dependency</td>
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<td>- undermine other’s ability to care for themselves</td>
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<td></td>
<td>- adjust cultural practices</td>
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<td></td>
<td>- technology transfer is difficult</td>
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<td></td>
<td>- unequal power relationships</td>
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<tr>
<td>The design of the program could easily fail to address the necessary concerns</td>
<td>- program may only have charity aspects</td>
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<td>- program may lack a critical analysis of globalization</td>
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<td></td>
<td>- program depends heavily on the attitude of administrators</td>
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<td>- program may try to be too ambitious</td>
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</table>

Table 6.5: Some limitations and liabilities of humanitarian engineering
6.5 The role of the engineer

There is a need and an opportunity for a Humanitarian Engineering program. There are some great benefits, but also some very important limitations. So finally, what is this *role of the engineer* in human development, poverty reduction, and disaster relief?

This question hits at the heart of this research project; it ties everything together and bridges the philosophical thrust of this thesis with the implementation part. Talking about the role of the engineer is difficult, however. Professional engineering bodies are made up of individuals who hold many different perspectives on their role, and the statements from their professional organizations are not specific enough to deal with issues of equality, social justice and human development. The following statement from the Institution of Professional Engineers of New Zealand, for example, sounds good, and although it is a very progressive statement for a professional engineering society, it does not give any specifics for work in marginalized communities: “Engineers will translate into action the dreams of humanity, traditional knowledge and values of science to achieve sustainable management of the planet through the creative application of technology” [192].

Most professional engineering governing bodies define the role of the engineer as involving the safety and well-being of *all* people.\(^7\) This thought, in light of all of the marginalization that exists, both locally and internationally, should cause all professional engineers to reflect on who really benefits from their work and how well their work does and does not benefit the most marginalized in society. This thought also led me to ask about the engineer’s ethical or moral obligation to work with the marginalized and for human development during the interviews. Many interviewees had trouble with the word *obligation*. In general, a moral obligation is seen as meaningless in an age of pluralism and relativistic standards with no singly accepted moral code, while a legal obligation is seen as impossible to enforce. Some quotations below capture this.

\(^7\)See [124], for example
I certainly would find it pleasantly surprising, I guess, but hard to imagine, that, as professionals, that there would be much appetite for the engineers to talk about this sort of obligation. I guess it gets back at this larger question of what is our obligation to other human beings in the community.

... Maybe I’ve been burned too much by using the language of obligation with people, because sometimes it gets people’s back up a little bit when someone else is telling them what to value as opposed to someone else trying to be an advocate for a certain set of principles. Walking that line is tricky. It is an important balance to strike — where you are able to say, here is something that will empower you to live out those values. That strikes me as something a professional organization could definitely do. (Ca1)

I do think it is our obligation, but the way the word is used popularly, the word obligation is easily dismissed. I don’t believe the word ‘obligation’ can effectively motivate people. (Ca2)

Therefore, the role of the engineer in human development cannot be described in any absolute terms, and thus it will be described based on the results of the qualitative data presented in the previous chapter. The following list contains some concrete roles for the engineer in human development that come out of the data; it is not exhaustive. It is also important to point out that these tasks are not exclusively for the engineer, but are often best tackled in multidisciplinary teams. The engineer does offer a variety of skills that non-engineer might not be able to apply, but the point of this section is not to suggest that engineers must be leaders in all of these following roles, but that they have a part to play.

1. The engineer can be a problem solver.

2. The engineer can help build capacity.
3. The engineer can create awareness through being an educator and an informed activist.

4. The engineer can influence policy.

The following sections describe these roles in some detail. A broad brush is used in these subsections to define the particular roles of the engineer in marginalized communities. There are obvious differences between the engineer’s role locally and internationally. These will be dealt with in Section 6.6: Implementation.

6.5.1 A problem solver

The first role of the engineer when working with the marginalized is simply doing what he or she was trained to do: solve problems. The engineer, as discussed in Section 5.1 (The social role of engineering), can make a contribution to both social issues and development through his or her problem solving skills [5.1.3, 5.3.3].

There is a challenge, though: while engineers are indeed trained as problem solvers, their curriculum focuses almost exclusively on training technical problem solvers. Not all problems are technical, and not all analytical thinkers are engineers. Development problems tend to have both a technical and social dimension. In a world where technology is often blindly discussed as a key component of many of our biggest challenges, it is necessary to expose engineering students to social studies, and a certain breadth is required in engineering education. This was stressed in Concept 2 (Changes to the engineering curriculum) [5.2.3].

Robert Chambers appeals for this curriculum change.

The technical and neutral appearance of many decisions and actions is deceptive. A decision ... to install a Modern Rice Mill in a South Asian country can be presented as entirely technical, based on consideration of milling out-turn efficiencies, benefit-cost ratios, and the like. [It has been calculated] that
running at effective capacity, one such mill in South India would put some 300 people out of work. [55]

The engineer needs to accept to work as part of a multidisciplinary team, in order to contribute to human development issues.

In marginalized communities, ‘hands-on’ skills are often critical for a problem-solving humanitarian engineer. At several NGOs that I visited in Ghana, development workers discussed their frustrations regarding the complete inability of the visiting western engineers in working with machinery. It was acknowledged that the engineers were not mechanics or technicians, but a higher level of ‘hands-on’ skills would have been appreciated. One interviewee suggested that this was the most technical task that most development engineers were really faced with.

The most engineering type skills that I saw in evidence were things like:

‘Such and such is broken, can you fix it with the things that are available?’

(Ca1)

Another concern with labelling engineers as problem solvers is that when they are working in a community that is not their own, they can very easily find problems that are not necessarily considered to be problems by those in that community. When an outsider dressed as a problem-solver comes into a community to help, he or she immediately creates unnatural power relationships. Engineers in this situation must learn the challenging art of listening and waiting. Who is defining the problem? Why does it need to be solved? Who benefits and who does not? As mentioned in Concept 3 (An international humanitarian engineering placement), there are concerns with engineering work crossing borders (both physical and more abstract borders) [5.3.5]. One interviewee (Ca4) suggested that perhaps the humanitarian engineer can develop the framework of a design and take a minimal role afterwards, as the community works to see how to adopt it.

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8The classic proverb says: If you have a hammer, every problem is a nail.
The idea of appropriate technology for problem solving came up in many discussions about the role of the engineer in development; the engineer is responsible for developing appropriate technology that is deemed to be culturally sensitive, community based, affordable, non-violent, with a minimal amount of social disruption [5.1.3, 5.3.3]. An example of appropriate technology came from one interviewee who was hired to solve the problem of contaminated water in Vietnam. He used locally constructed sand filters to effectively remove a large percentage of the contaminants from the drinking water.

As mentioned in Concept 3 (An international humanitarian engineering placement), technology is a cultural entity, and care must be taken when it is transferred to a community in which it was not initiated [5.3.5]. The key to applying appropriate technology is to enter into community with the recipients [5.3.6]. Appropriate technology is not implemented quickly. Like the terms ‘sustainability and ‘development’, the phrase ‘appropriate technology’ can be used to mean many things and can simply become a term of convenience. The real meaning behind the term must embrace professional humility and community participation.

There are some who say that appropriate technology is discriminatory. Why should the rural marginalized get a lesser technology? This brings up the question of the humanitarian engineer’s role in large-scale and high-tech development. It is clear that many marginalized communities want higher technology — this came up in several interviews. Images of affluence reach down to the most impoverished communities, and Western technology, especially mobile phones and consumer electronics, has great appeal. This complicated issue brings us back to asking why anyone should bother intervening into another community in the first place. Surely it should not be to convince others to live more like us, or to create more consumers [5.1.5]. With all of the potential problems of intervention, working with a marginalized community must be done for issues of justice and equity.

While there are some cases where the most appropriate technology may be a high-tech solution, often the most appropriate technology is an intermediate technology.
Humanitarian engineering obliges the engineering student to take a critical look at modern technology and the associated lifestyles — the more advantaged also need to learn to live with less.\textsuperscript{10}

A distinction, however, needs to be made between low-tech and ‘low science’. Low technology does not mean simple science. Kammen and Dove argue that the technology needed to help with human need often requires a remarkably large amount of science and research [134]. They say,

\begin{quote}
Academic definitions of “cutting edge” research topics exclude many of the issues that affect the largest number of people and have the greatest impact on the environment; everyday life is rarely the subject of research. ... Finding solutions to these [everyday] problems does not require less sophisticated research or environmental management, yet support for work on these mundane topics is weak relative to their importance to humans and the environment. [134]
\end{quote}

\section*{6.5.2 A capacity builder}

Just like ‘appropriate technology,’ the term ‘capacity building’ is extensively used and misused in development discourse. Capacity building has to do with training to empower people, creating opportunities, or equipping others with useful skills. Building capacity is related to problem solving, except the premise is that the community members should solve the problems with as little outside intervention as possible.

In most developing communities where the real problems are seldom only technical and mostly non-technical, capacity building must include more than the creation of a technology. Thus the engineer who is working cross culturally requires both the technical know-how and increased social awareness, discussed in Concept 2 (Changes to the engineering curriculum) [5.2.4]. In the example of the sand filters, the biggest challenge was in

\textsuperscript{10}It is hypocritical to promote ‘Small is Beautiful,’ unless it is also demonstrated.
providing the technical support to the communities to keep the filters working correctly; the difficult task was in training the local people to turn around and apply the technology on their own. The role of the outsider engineer was in building capacity. One interviewee said the following about international engineering and development work:

> It is not the engineering skills that are useful, but the way that the engineer thinks. The engineer’s analytical, organizational ways of thinking are essential for teaching Africans to teach themselves. ... Engineers have a huge role as a facilitator in increasing office efficiency and making aid more effective. The engineer can help start small businesses and help farmers know what they are signing. (Ca3)

Capacity building is often presented in a way that makes it less imposing or patronizing than appropriate technology or technology transfer, but often it can be equally condescending. While applying appropriate technology can assume that an outsider knows the necessary technology, capacity building can assume that an outsider knows the necessary skills. The previous quote assumes Africans need someone to teach them how to care for themselves. In reality, capacity building can impart necessary skills, but it also can artificially give one person power over another, especially if only a few members of a community are trained on how a new technology works.

Teaching skills to create livelihoods is a critical aspect of capacity building. Albert Einstein said that, “In the case of political, and even of religious leaders, it is often very doubtful whether they have done more good or harm. Hence I most seriously believe that one does people the best service by giving them some elevating work to do and thus indirectly elevating them” [62]. Creating jobs can be a useful way of spreading money around.\footnote{In some parts of Ghana, it is traditionally believed that if one has money, it is expected that they hire people to do domestic work. It is a great shame if someone has a lot of money, but does not have nice gardens, because that means that they have not hired a gardener.}
Again, properly building capacity must have to do with the needs of the community [5.3.6]. Much thought is needed to ensure that the benefits of thoughtful capacity building outweigh the ‘unforeseen’ consequences.

### 6.5.3 An educator and an activist

The next potential role of the engineer is that of the educator. This is related to the previous role of capacity builder, but in addition to the teaching of skills, the engineer must also teach about awareness of issues and linkages [5.1.5], both explicitly and with subtle suggestions for social change [5.5.3]. For example, building a sand filter and developing community leaders to keep it running are important, but the clean water is useless without an understanding of the importance of both washing hands, and why traditional water sources are no longer potable. Thus the engineer, ideally as part of a larger team, is important for the creation of awareness and the broadening of ideas for the issues linked to technology acquisition [5.2.3].

This role is thus necessary to teach technical literacy, but must also include a critical analysis of technology and its interaction with the social. Ursula Franklin argues that in teaching technical literacy, we must go beyond the ‘gee-whiz’ state and understand that in many cases technology is anti-people [10]. It is challenging for an outsider to cross a border with a new technology for a low-income community and in turn instigate discussions on the potential negative impacts that technology will cause socially. We rarely have enough foresight when new technologies are introduced in our own neighbourhoods. This, however, is essential, says Franklin.

Will those who advocate greater technological literacy today teach their students to read between the lines of what they experience of mathematics, science, and technology? ... Such knowledge is needed to allow a critical understanding of some of the most powerful forces of our time. [10]
Just like technology, education is often cited as a quick fix to a multitude of world problems. A key theme of this thesis is about the importance of education, but it must be a specific type of education [5.2.5]. While education truly is one of the great answers, this statement is as benign as saying that attitude or perspective will fix the world’s problems. We must be aware that the government of the day sets the curriculum to suit its own political agenda [129, 200]. Illich argues against universal education and describes the nature of institutionalized education as ineffective and instead encourages self-directed education supported by intentional social relations.

Neither new attitudes of teachers toward their pupils nor the proliferation of educational hardware or software, nor finally the attempt to expand the pedagogue’s responsibility until it engulfs his pupils’ lifetimes will deliver universal education. The current search for new educational funnels must be reversed into the search for their institutional inverse: educational webs which heighten the opportunity for each one to transform each moment of his living into one of learning, sharing, and caring. [200]

There are many people advocating for increased access to schools worldwide, but how should we react, for example, when education means that children no longer learn skills from their parents, but are instructed by a schoolmaster who takes instructions from the state? Education is far from neutral. Engineers working in marginalized communities have an opportunity to be a valuable voice of training, awareness, and social location, as discussed in Concept 1, 2, and 5 of the previous chapter, but must ensure that the education they promote encourages convivial learning and living.

Much like the previous two roles, the humanitarian engineer as an educator is useful in his or her own community as well. In fact, this may be her or his most important role, especially when questions about the social consequences of technical change are posed [5.5.3].
Creating awareness is only the first step in addressing problems; knowledge without direct and effective action is useless. For this reason, the humanitarian engineer must act on the knowledge as well. This action can involve problem solving or capacity building for marginalized communities. It must also involve lifestyle decisions and often includes acting against oppression in many forms. Working to change the inequalities in life is not an easily mapped-out path, but somehow, the impoverished must be supported and those of us who impoverish by our actions, our consumption, our involvement in unfair social structures, and even our ignorance must be encouraged to change [5.5.4]. Riley concludes that

Engineers can and should resist neoliberalism in global development. The neoliberal ideology has led to policies and outcomes including increased economic inequality, environmental devastation, violations of human rights, oppression of women, widening technological divides, and suboptimal engineering solutions. Active resistance is needed from the profession in order to address these injustices ... in such a way that results in student action. [103]

Supporting advocacy groups and local initiatives is important, but it is not enough to simply give money — there must be a deep understanding of where the money goes. Many NGOs exist to make money. In fact, there is a saying in Ghana, according to one interviewee, that says, “If you want to make money, start an NGO” (Gh3). I heard this quote several times during my travels. Another interviewee from a low income country said a similar thing:

There are lots of NGOs who are real corrupt. I have seen them. They will go to these poor communities to take pictures, video to send over so we can help them. But you get money from these developed countries, and it goes in their pockets. (Ca9)
6.5.4 An influencer of policy

The final entry in this list is again related to the previous one. The activism of a humanitarian engineer can influence policy to try to effect how our communities are governed [5.5.4]. Engineers are often silent in political debates, yet are well suited for it because of their technical skills and understanding of many processes around which exploitation occurs, such as resource extraction, product development, and material selection. Engineers should not be silent on issues of global subsidies, tied aid, and globalization, for example.

Those of us in the rich world are often spatially remote from the poor, but are part of a global system which maintains poverty. We can help ourselves and others by not only better understanding the issues and linkages, but by lobbying for better terms for trade and for better programs of aid, and by advocating for campaigns to stop abuses which harm and impoverish those who are already poor.

Wright advocates for more engineering students to get involved in politics and argues that they can affect government-level decision making processes if they do. He says, “the [engineering] student should be shown how an involvement in politics can improve the positive outcomes and reduce any negatives of professional engineering decisions” [192].

Much of the discussion about the data has stressed the importance of focusing on community [5.2.4], and it is sometimes hard to focus on community and also see the big picture. This is, in essence, the challenge of humanitarian engineering. The two main themes of the role of the humanitarian engineer are, according to the data [5.2.4, 5.5.4], to

1. Build strong community

2. Resist, challenge, and engage the forces that cause marginalization and impoverishment at home and abroad

While one of these ideas looks inward and the other outward, they are not necessarily mutually exclusive. They are both associated in living with integrity and living with
intentionality and one more balance that every individual needs to struggle with.

Table 6.6 summarizes the roles of the engineer to be stressed in a potential humanitarian engineering program.

<table>
<thead>
<tr>
<th>The engineer as a problem solver</th>
</tr>
</thead>
<tbody>
<tr>
<td>- must consider both the technical and social components of the problem</td>
</tr>
<tr>
<td>- often requires ‘hands-on’ work</td>
</tr>
<tr>
<td>- not all ‘problems’ need a solution</td>
</tr>
<tr>
<td>- solving problems can require appropriate technology</td>
</tr>
<tr>
<td>- solutions can be both complex or simple</td>
</tr>
<tr>
<td>The engineer as a capacity builder</td>
</tr>
<tr>
<td>- empowers and creates opportunities, livelihoods</td>
</tr>
<tr>
<td>- can still be imposing and patronizing</td>
</tr>
<tr>
<td>The engineer as an educator and as activist</td>
</tr>
<tr>
<td>- informs and creates awareness for positive change</td>
</tr>
<tr>
<td>- involves a technical literacy beyond the ‘gee-whiz’</td>
</tr>
<tr>
<td>- education in itself is not neutral</td>
</tr>
<tr>
<td>- important in own community</td>
</tr>
<tr>
<td>The engineer as a policy influencer</td>
</tr>
<tr>
<td>- engage the forces that cause marginalization</td>
</tr>
<tr>
<td>- lobby and advocate for effective action</td>
</tr>
</tbody>
</table>

Table 6.6: Some possible roles of the humanitarian engineer discussed in the data

To conclude this section, there is a need for humanitarian engineering and the opportunity is present. The benefits can be great, but the limitations and liabilities cannot be ignored. The engineer can contribute through solving problems, building capacity, educating, creating awareness, being an activist, and influencing policy.

These roles can only be carried out if the engineer can be trained with humility. This is a challenging task. One interviewee captured this idea:

It’s tough because we try to get our students excited about technology, they are after all, engineers. But we forget that some of the very best engineering contributions are the simplest solutions. The most socially responsible engineers will be the ones who get the least glory. They’ll be the ones who have
that refined common sense, who are content without making a splash, who are content just to be good people. That is a very difficult thing to educate anyone to be because almost anyone who goes to university goes for reasons of ambition. (Ca13)

6.6 Implementation

What could a humanitarian engineering curriculum look like?

The intention of this thesis was to discuss the philosophy and implementation of Humanitarian Engineering in the engineering curriculum. The previous sections highlighted much of the philosophy behind humanitarian engineering, and there have been several allusions to the implementations, but it is now necessary to discuss implementation ideas from the data more completely. The discussion here connects closely to the discussion in the previous sections: a strong curriculum will focus on the benefits and pay heed to the limitations, for example.

Before proceeding, it is interesting to note that in many of my conversations and unrecorded interviews, there was a real tension between the philosophy and implementation of humanitarian engineering. Many people wanted to talk about the need or the benefit of such a curriculum change, while other people wanted to talk about exactly what it would look like. In the Humanitarian Engineering Discussion group, when participants were asked to pick topics for discussion, this same phenomenon was witnessed.

There was an overwhelmingly favourable response to the concept of a humanitarian engineering program. Many people had strong and important warnings (most of which are mentioned in Section 6.4: The limitations), but no one came right out and said that humanitarian engineering was a bad idea. Some people saw it as a great business opportunity, others as a means for social justice, and many things in between. In the end, any university that is interested in incorporating humanitarian engineering into its curriculum
must consider how to shape the institution to address the need.

This section is broken into three subsections: curriculum, placement, and the office.

### 6.6.1 Curriculum

During the course of this project, I spoke a great deal about bringing humanitarian engineering ideals into the curriculum. This was usually correctly taken to mean more discussions about the role of the engineer in marginalized communities at both a technical and a non-technical level. However, it remained somewhat unclear exactly what that curriculum would look like. The intent of this next subsection is to briefly discuss some thoughts and ideas that have come out of this research. Much of the ideas presented below are extended from discussions in Section 5.2: Changes to the engineering curriculum. Many other curriculum ideas are in response to some of the possible limitations listed in Table 6.5; proper curriculum design can overcome many of these liabilities.

1. **A module to which all engineering students should be exposed.** Humanitarian Engineering definitely needs to reach everyone [5.2.2]. Not everyone will be automatically drawn to it, but it is essential that everyone is exposed to it. If Humanitarian Engineering were considered to be an optional module, this could give the wrong message about the rest of engineering as being non-humanitarian. For this reason, it is necessary that humanitarian engineering be treated as a philosophy and not as a separate department.

   The amount or length of this exposure is a critical parameter. A lecture or two or a half day workshop\(^{12}\) would be the bare minimum requirements. Perhaps a week or two of lectures could give students a solid historical and cultural background. On the other hand, if there is too much discussion and the material is not subtle enough, students can quickly be turned off.

\(^{12}\)Queen's University currently exposes every engineering student to a 3 hour Humanitarian Engineering module during their APSC 190 course.
It is also imperative that this module is taught in such a way that the students take it seriously. This is a significant challenge that will require a certain amount of unlearning [5.2.5]. This is, perhaps, one of the most difficult aspects of the implementation, as indicated by the following quote.

JDJV: What sort of changes would you propose, if you do in fact think it is necessary?

Ca13: The implementation baffles me. I don’t know how you try to reverse 100 years of tradition in an academic faculty of all places. The obvious place to start is in the first year linkage courses when [students] are at their most impressionable. And somehow you also have to create the impression that it is not a bird course. Above all things you have to avoid flaky or wishy-washy topics. You do not want to be perceived as to just paying lip-service to what are very important issues.

A dedicated and passionate instructor can be instrumental in overcoming this obstacle.

2. **New, additional courses for those who want more.** Students who wish to study engineering and human development issues further should have courses available to them [5.2.1]. It is beyond the scope of this thesis to detail additional courses that could be added, but the most interesting, additional courses are mentioned briefly below. Appendix G lists other potential courses that could be of interest.

The most important course that should be developed is a general course on engineering and human development. This course should include material on historical and cultural context; possible appropriate technologies such as solar cookers, rain-water catchment and straw-bale houses; indigenous knowledge; case studies; local communities; communications; social impact analysis; social justice and activism. This
course would have to have both technical and non-technical components. Care would have to be taken in how the course presented appropriate technology [5.3.3]. Appropriate technology is sometimes seen to be patronizing and viewed as obsolete, inferior technology, yet especially in a time where we are drawn to high-tech solutions, there is merit in seeking simpler, less extravagant technology in both developed and developing communities. One interviewee said, “I would be careful to do it in ways that do not reinforce the view that [appropriate technology] is second rate engineering. (Gh9)” Another danger in teaching about appropriate technology is that it might be giving the message to young engineering students that technology can solve any problem. Technology must be taught as something that plays only a part in the broader picture of human development [5.1.4]. Communications would be another critical component of the course, and it would be essential to differentiate between learning languages and learning to communicate with people from a different culture or class [5.3.3]. Another necessary course could be a course on engineering and social justice.\textsuperscript{13} This course could teach the students about creating change through confronting hierarchical structures in order to democratize power in the workplace, at school, and in society [5.5.4].

3. **A broader curriculum.** Giving engineering students a broader humanities or liberal arts focus would create a more rounded student [5.2.3]. While it is obvious that technical skills are essential for the competency of the problem solver, awareness and social skills do not compromise, but rather enhance, this competency. Keeping this in mind, competency comes in large part through teaching about responsibility and

\textsuperscript{13} Queen’s University already offers a popular, multidisciplinary, second year course called MDEP 221: Engineering and Social Justice.
skills in accessing information. It is impossible to teach all of the technical information an engineer may require, and thus the goal of engineering education cannot be simply to fill a student’s mind with theory. Much more important is teaching the engineer to seek out algorithms and ask questions in order to develop potential design solutions. With this thinking, there should be adequate time to give a broader, interdisciplinary perspective. In addition, a social understanding can give meaning to knowledge and create an environment where the designer has a greater personal involvement, thus leading to greater incentive, and thus higher competency. So a socially aware engineer will be more competent.

It is a little bit like water [treatment] — you can design some hardware, but if you don't understand the science, it won't work. If you understand the science, much better. You can really optimize the reactor if you understand the fluid mechanics. It is the same thing with environment, economic, social impact — you can again miss the target. The broader the education in that sense, the better the engineer you are going to be. (Ca16)

A broader curriculum must be presented in a way that engineering students see the social sciences courses as important and complementary to their technical courses. History courses are vital here: not only is it necessary to understand the sometimes shameful history of engineering, but a historical view of the legacies of political and economic interventionism in the past can enlighten engineering students about the current climate in which they will have to work.

Engineering courses are often taught from a very objective point of view. To counterbalance this approach, a wide exposure to art, science, economics, math, politics, literature, religion, philosophy, society, and history will give engineers a better ability to understand the interconnections of issues and the subjective nature of many of the challenges that engineers could face in their careers, more so now than ever before.
Engineers do need to be more subjective, not only because that leads to a more balanced person, but also because that is what engineering is. Engineering is both creative and analytical, but the educational system focuses on the objective side, in part because it is easier to teach and mark. One professor said that “creativity is a really tough thing to teach. ... We need to allow opportunities to explore it, but we don’t give [students] opportunity or time to think about creativity. We give them closed ended problems. (Ca5)”

A broader education will also allow for more communication with students with different skills. This is a necessary skill for an engineer to develop.

There is no engineer who can solve all problems. The skill set we really need to learn is to be able to put everything in context and then to really work with other people who can complement your work. ... This requires a sensitivity in knowing your limitations so that you go to other people to interface. You need a lot of people skills and social skills. ... Nine times out of 10 it is not a technical problem, but we still need to be technically competent. (Ca16)

4. Adjusting existing courses. Currently, engineering courses are filled with discussion and examples that have to do with economics, business, and industrialization. These issues, especially economics, are not necessarily intrinsic to engineering. In a similar manner, it is suggested that engineering education, where possible, be infiltrated with ideas related to social justice and work for the marginalized [5.2.4]. There are many engineering topics in which it would be easy to discuss issues of environmental or social sustainability, either briefly or comprehensively. This would be another way in which humanitarian engineering ideals could reach every student [5.2.2], and it can occur within the current framework.
For example, it may be difficult at first glance to connect computational heat transfer, to the needs of the marginalized, but it could be through subtle messages such as worked examples. Many example or assignment problems in engineering involve industrial processes; it would be just as possible to study heat transfer through a straw-bale house as through an industrial furnace. It is also possible to build some engineering history into a wide variety of engineering courses.

The success of this sort of idea would depend on the willingness of the professors to co-operate. A Humanitarian Engineering Office could help willing professors think of ways to incorporate ideas into their curriculum. If entire Faculties or Departments were interested in this sort of curriculum change, these adjustments could be administered using teaching evaluation forms or teaching reviews. Much like the introduction of a business component in the engineering curriculum at all Canadian schools approximately 30 years ago, it is feasible to think that there can easily be a human need component as well. This has potential to effectively adjust the way engineering is taught so students are more aware of the world around them, as long as it is not over-done.

5. **Seminars.** Many of the issues that need to be discussed do not have easy answers, but often the answers are not the most important thing [5.2.2, 5.5.3]; Epprecht suggests that the dialogue is what is really important. He says, “It is clear that it is the importance of the questions and the necessity to ask them that counts, not the dogma of the answers. [156]” There is a great pedagogical advantage in introducing knowledgeable speakers and having regular discussion times to identify problems and discuss possible solutions.

6. **A capstone project.** Open design courses are useful for giving the students flexibility in learning or researching something that interests them. Independent students can often get a great deal out of this inquiry type learning [5.2.3]. A specific design
course can be created with the purpose of considering the needs of an impoverished community. This would, of course, require a deep understanding of the community in question, but would offer an opportunity to think about both technical and non-technical components of a project.

There are large dangers with this sort of design project. It can be fun, but it could also give the student the idea that they could read a case study and be able to fix a real problem without experiencing the social and cultural environment. But this sort of project could be done either with a local community or in conjunction with a placement. Regardless of how it is done, the student must be mentored and reminded many times about the risk of being patronizing. At the very least, the project must have a thorough social impact analysis of the technology.

7. **Placement or internship.** Perhaps the most apparent potential curriculum addition would be that of a placement or an internship in a low-income, marginalized, or impoverished community for an academic credit. This could be overseas or local. It could be 4 months, 8 months, a year, or longer and could be tied into seminars or design courses. More will be written about this in Section 6.6.2.

8. **An undergraduate specialization.** It would be possible to administer a Faculty-wide specialization in which a student gets specific recognition for taking a specific number of courses, projects, seminars, or placements [5.2.1]. This specialization should be available to any student regardless of their discipline, and could be done within the university’s 4 year program or as a 5th year add-on. The following quote captures some of the opportunities that could be available with an undergraduate specialization.

   There is a real opportunity to think about undergraduate education in
Canada in a much more holistic and integrated way. Why don’t our students work on something in first year and then revisit and expand on it in a second year course and then further develop their thinking with a placement or more practical work. I think we do a very poor job of making our education more integrated from year to year. ... We come up with a research problem. We test it. We learn that we’re idiots and we revise it and we try it again. That’s how science happens and we model that very little in our curriculum. (Ca1)

9. Humanitarian engineering at the Master’s degree level. From an administrative point of view, a Masters (or post-graduate) level program would be even easier to administer because much of the framework is already available. It could even be done through a 1 year course-work Masters or a 2 year thesis Masters. The placement could be counted as a course or could be the backbone of the research thesis. There is potential for a given school to have both an undergraduate specialization and a Humanitarian Engineering Master’s degree; the students could interact and learn from each other, and perhaps some courses could even connect the Masters and undergraduate students [5.2.1].

The following quote addresses some of the advantages of implementing Humanitarian Engineering at the Master’s level.

I think it would be better to have a Master’s Degree, so that you would have a basic foundation in engineering and then you would go off in two years focusing on those details. I’m a big supporter in leaving the engineering program alone and then if you want to focus your attention, you do that in some sort of graduate degree. Then you don’t need big numbers. (Ca14)
The fact that this could work with a small number of initial students makes this a promising place to start a Humanitarian Engineering initiative.

This list is only a start of curriculum changes that could be made. A university interested in making adjustments could use these ideas as a beginning, but a well planned implementation strategy is crucial. While there are many people who have expressed discontent with the education system and the high degree of specialization, there is also a large resistance to change. Often the people who are in a place to make decisions have found their position in the existing framework and want to protect how things are done. Ideally, the engineering curriculum is adjusted in a radical way, but the ideas above would also allow for more gradual adjustments. The following quote, in fact, suggests that perhaps small steps are the best model for change.

I don’t think we need a clear vision on what [engineering education] has to be at the end. Because we are talking about huge change. Because of the immense magnitude of that change, it is important that we take steps rather than try to sort out the whole big picture because, I know it is a worn out phrase, but it is a huge paradigm shift. (Ca11)

In the end, if administered and delivered correctly, a humanitarian engineering curriculum can produce at least three invaluable outcomes. It can enlighten engineers on further career options, it can lead engineers down a path to be more balanced people, and it can create a deeper awareness of social location. The following quotation captures some of these sentiments:

Not everyone can become a development worker and not everyone wants to. And that’s not really what we want out of [an additional course]. But just to show a process in the way of thinking and the bigger picture and the sort of impacts of your actions within Canada and overseas. If you work with an
engineering company, for example, that they can have a broader impact and awareness — social, environmental and cultural ideas. So it is sort of the development of the whole person. (Ca3)

6.6.2 Placement

There has been much said over the past couple of chapters about placements in a marginalized community for an academic credit. It has been acknowledged that the placements are neither intrinsically good or bad [5.3.6]. The goal of this subsection is to leave the debate behind and briefly discuss the details of the implementation.

The success of a placement is going to depend on:

- the attitude of the student
- the details of the receiving community
- a good match between the student and community
- good organization, administration, and preparation

The first and most important component for success is the student’s attitude [5.3.3]. Humble, congenial, compassionate, and understanding people are necessary. It is hard to teach these qualities in an engineering program, but it is essential that they are sought out if a student is going to cross a border into an impoverished community. One interviewee who has been involved in many international development projects throughout the course of his career said that “a project will be as good as you want to make it. The difference between a good project and a bad project is student approach. It is far more about relationship than it is about engineering” (Ca15).

So how is this type of student found? In the end, the student must have both good intent and deep awareness. Many interviewees expressed great concern that poor ambassadors will be selected and sent. The following two quotes suggest certain attitudes that
must be avoided.

I’m concerned when I hear some students talk because it is almost like a vacation for them. It’s poverty tourism. That we really have to avoid. There’s no place for that. (Ca5)

Above all things, you want to avoid encouraging resume padders who pursue things for all the wrong reasons. ... The resume padders come in two breeds. There are the ones who are guilt tripping and those who want to serve their own ambitions. You don’t want to reward those people. (Ca13)

It is not easy to know who to send and who not to send, but it is clear that not just anyone should be selected. A thorough interview should be the bare minimum in the student selection process, and only appropriate students should go. A student should not necessarily be selected for every available position, just to fill the position. One interviewee offered the following advice for student selection:

The starting place is a sensitivity to all of these issues (paternalism, colonialism, orientalism, power relationships) and that may mean that something that started off as a good idea to begin with isn’t a good idea. We have to recognize that holistically, if it is not a good idea, we’re not going to do it. We can’t simply say, ‘Well, this student needs credit for a placement, you have to take him.’ The deeper questions about what sort of relationships are being built and what kind of mutual benefits are being fostered? Those sorts of questions can easily be sidelined, and they really need to be central. And if that means we can’t have a placement for somebody, we have to get to a point where that is OK. (Ca1)
Experts suggest that outsiders must keep their mouths shut and their eyes open during the bulk of the beginning stages of a placement [55]. That time should be spent investing in community and seeking commonality. The most successful placements will involve students who understand that how they can best help is probably very different from what they initially anticipated and their contributions will be best discovered if they focus on learning and understanding the relationships.

One interviewee argued that once the right student was selected, many placements could be appropriate. “You see,” he said, “if anyone who works in an aid program, if he or she thinks they can contribute a lot to others, yes, she will contribute. (Ca15)” The details of the placement are, however, important for the success of the project [5.3.2].

Ideally, students end up working with a mentor who is already familiar with the receiving community. Thus it is necessary to have the best contacts or collaborators possible. Creating this sort of network takes time and experience, although there are often many good starting places due to the rich cultural diversity at most Canadian universities. Exactly what projects are undertaken will be moral, economic, and social decisions, and the exact implications of those decisions can never be predicted. Working with one community over another can create hard feelings.

It was good to be with an organization that has connections and has been in the country for a number of years. You can’t underestimate the benefit of having a reputation in the country and having experience there. (Ca8)

A student’s integration with the community will be critical [5.3.3]. This is sometimes successfully done by placing the student with a host family, when possible, something that again is a challenge to administer. It is sometimes tempting to send multiple students to the same community, but students are often more successful at integration when they are on their own.

A good match between the student and the community. It can also be a good idea
to repeatedly send students to the same community, but *continuity* will be another critical issue to keep in mind. Having sensitivity can make the difference between a community seeing itself as being used as a platform for an outsider’s education and travel, or being a part of a bigger project. The longevity with a partner can help maintain relationships with dedicated staff. There is also great opportunity to have long term links with other academic institutions. Multiple trips by the same student has significant financial implications, but could also offer some impact and pedagogical advantages, especially if the placement is tied-in with a design course or seminar. The exact details will have to be worked out, but there is a very important advantage when the placement is part of something bigger.

The main idea is to make [the students] aware and educated about what is going on. In the long term, we can have [the placements] all together. We can put the work of all of the different students and put it together and have it really help that community. And we can use the results of the students work with government or international agencies to get together as well. Otherwise, it would be hard to get something really concrete done. It has to be part of a bigger thing. (Ca9)

Matching the interns and their technical, cultural, and communication skills to a community is another hurdle that should not be taken lightly. It is hugely important, and usually done in relative isolation. Safety, travel and expenses are other factors that must come into play when matching the student with a potential community.

Even after all of the above is considered, the placement could be unsuccessful without **proper planning** [5.3.2]. This includes pre-departure training, a sustainable exit strategy, and post-placement reintegration. The plans need to find a balance between thoroughness and flexibility. Some of the best advice that I was given before my trip to Ghana was that I should plan out as much of the details as possible and then throw the plans away upon arrival. That advice was useful for me. There is a seemingly infinite number of
tasks to consider when crossing borders, and organized administration can easily make the difference between a good project and a failure.

A sensitive exit strategy is required to ensure sustainability and a good relationship with the host community. This will depend fully on the nature of the project and whether the placement fits into a bigger project.

Planning for reintegration is equally important. It is very important for the students to have some time to process their experience upon return. Many people argue that reverse culture shock is far more difficult to adjust to than culture shock. One interviewee said that he and the group he travelled with “were very confused at the end of it. We were across the world and getting ourselves immersed in a different culture. But in the end, how does it change anything, how I live my life and where I go from here. Was I just supposed to go and get an engineering job?” (Ca8). He said that telling his story was a very useful way to adjust and process the event. A student presentation upon return would then serve two purposes: a chance for the intern to tell a story and a chance for the student body to learn from the experience as well.

**International placement**

The international placement offers very different implementation challenges than local placements, for many obvious reasons. But along with the great administrative hurdle, the learning benefits are also many, and there seems to be an overwhelming interest in international placement from both sides.

The number of possibilities for placements is great; the following list offers a number of ideas that are currently available through contacts some of my colleagues and I have made over the last few years.

- Wind power in Nicaragua using local knowledge and materials through a not-for-profit company called Blue Energy.
• Implementing efficient cookstoves and multifunction platforms in northern Ghana with Kumasi Institute for Technology and the Environment (KITE).

• Developing a plant fibre/waste plastic composite material in Lesotho through a current research project at Queen’s University.

• Integration of a waste water garden in Indonesia through a partnership with Institut Teknologi Sepuluh Nopember (ITS).

• Water or livelihood projects at Constance Lake First Nation’s Reserve.

• Water quality project in Mylai Balaji Nagar Slum, India.

Another possibility is what has been called the reverse international placement, in which community leaders are brought to a Canadian university and take courses and work on design projects with Canadian engineers using the lab facilities here. This sort of idea has much potential, especially when done in conjunction with a more traditional placement and a research project.

We should be bringing community leaders here. They have a lot of engineering problems and we’re going to send an engineering student. [Forget] that. Let’s bring their leaders here. ... There are so many amazing leaders who haven’t had the level of education or access to the level of information that we have access to. (Ca10)

This idea was also brought up by a Ghanaian interviewee:

Movement in the other way could be beneficial. The [Ghanaian] students believe that life in Canada and USA is heaven. It would be good for them to really see it. (pause) The problem is with the people who go and don’t come back. (Gh5)
Local placement

The local placement is perhaps easier to administer, but has some significant challenges of its own. Issues of liability and perceived legitimacy must be addressed, for example. The expenses are obviously very different as well.

With the right students, it is exciting to think of what can be done and what can be learned, although it is important to remember that there are many dangers and challenges as well — many similar to those discussed in Section 5.3. There are many possible projects in this sector as well; some are listed below. At initial glance, some may seem a bit less engineering focused, although there are probably more chances to apply technical engineering knowledge in local placements than international placements, where the cultural constraints take significantly more effort to comprehend [5.4.4].

- Composting and community garden system at Martha’s Table, a community restaurant with a popular, affordable meal program.
- An energy efficiency consultant for the local Habitat for Humanity office or a local homeless shelter.
- Development of an engineering and technology awareness certificate program for young adults with physical and mental disabilities through H’Art Studio, Community Living, or Ongwanada.
- Design and implementation of a community drop-in centre and homework tutoring.
- Working with bicycle advocacy groups to promote more bike lanes for environmental reasons, but also to increase the ability of those without cars to get around and access city services.
- Design of an affordable bicycle trailer for Yellow Bike Action.
• Design and delivery of a technical literacy (that goes beyond the ‘gee-whiz’ state\textsuperscript{14}) and critical analysis curriculum for the local school boards.

• Expand the Run and Read program already under way at several local low-income primary schools.

• Bridging the gap between residents and city engineers for needed infrastructure.

• Creating an opportunity for local engineers to get involved with \textit{pro-bono} engineering.

• Research the need for and availability of affordable and energy efficient housing.

• Create a Kingston outreach program to educate others on issues of social location and how we often de-privilege others.

• Exploration of other ideas on how engineering skills can be used for the marginalized in the Kingston community.

\textbf{Length of placement}

An issue that came up in many conversations was that of an appropriate length for a placement [5.3.3]. Four months is an obvious length to consider because it conveniently fits into most universities’ academic calendar, but it is worth considering other options as well. Epprecht, in his research on development placements, uses a tunnel analogy. If a tunnel is too short, one’s eyes never adjust to the change in light; if one wants their eyes to adjust, they must be in the tunnel long enough so that they do not focus on the end of the tunnel. He suggests that 6 months is the minimum acceptable length [156].

Most people acknowledged that four months goes by very quickly and that the host probably does not get much out of a four month placement, as there is too much time

\textsuperscript{14}See Ursula Franklin [10].
training the interns. On the other hand, four months could work if the project is part of something bigger and the students were well prepared prior to the placement itself.

One interviewee who was involved in an international placement said that he was just starting to get comfortable with the day-to-day task after 4 months. He suggested 8 months, suggesting that doubling the time spent quadruples the productivity. Other interviewees suggested similar things.

It takes time to get the project going — time is a different issue over there. It takes 2 months to get immersed in the culture. At the end of my 5 months, I was still touching the tip of the iceberg. Language was just starting to be useful. You do need to get your mind adjusted, feel part of the community. An eight month placement would be by far better, but 4 months is better than nothing. (Ca8)

[The placement length] should for one, be longer than a summer job because a summer job is usually long enough to train you at something and then to ship you back out — especially when you have a new culture to learn. So I would say, 8 months to a year and for one, that also weeds out the students who just want to do it for resume padding purposes. That is a real test of endurance. Nobody who wants to add a letter to their resume by having fun abroad will commit to a full exhausting year. I think that is a good way of screening people. I think it is more realistic in that they’ll have a chance to learn something and apply it and it also removes them from the tourist experience. I’ve heard someone who says that if it is under 6 months, you are a tourist. (Ca13)

Four months for a placement is too little. You spend two months trying to figure out what is going on. By the time you figure out what is going on,
you have two months left, and then you have to figure out how to make your project work and get it going. When you are moved into a new cultural, social context, you become totally lost. It is totally overwhelming and you won't be able to function meaningfully.

I would argue in my experience, I only became really effective in what I was doing after a few months, leaving me with about 3 weeks to actually do anything. That was a time by which I was comfortable with the language, with my local NGO, with the situation I found myself in to actually work meaningfully. Beyond that I was just totally overwhelmed. I had no idea what was going on. And I would argue that that would often be the case for many people, particularly if they work in an area of a foreign language that people don't know.

So, I would recommend placements being at least 8 months. Then the project will benefit, the people will benefit, and humanitarian engineering as a whole will benefit. (Ca2)

A year or a 16 month internship would certainly keep the less serious people away, but it would also mean that more of the available resources would be spent on a single person. A year would be very appealing to ensure continuity; a little over a year would allow for overlap between students. In the end, the placement length will have to be determined based on finances, schedules, and partners, among other things. The ideal length for a placement, in many ways, is very project dependent. Ideally, there is some flexibility in how long each placement is. Four months is probably very appropriate for a local placement because the language and communication issues are much less daunting. Figure 6.7 gives a short summary of the pros and cons of various placement lengths.
### Length Pro Con

<table>
<thead>
<tr>
<th>Length (Months)</th>
<th>Pro</th>
<th>Con</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Fits academic calendar</td>
<td>Not enough time, too short</td>
</tr>
<tr>
<td>6, 8</td>
<td>Past steep learning curve</td>
<td>Not fit into program, bigger project</td>
</tr>
<tr>
<td>12</td>
<td>Project continuity</td>
<td>Expensive, fewer students</td>
</tr>
<tr>
<td>12+</td>
<td>Student overlap</td>
<td>Expensive, fewer students</td>
</tr>
<tr>
<td>16</td>
<td>A school year and two summers</td>
<td>Expensive, too long</td>
</tr>
</tbody>
</table>

Table 6.7: Seeking the optimum placement length

#### 6.6.3 Humanitarian engineering office

In the same way that a placement will only be successful with a student with the right attitude, a humanitarian engineering program will only be successful with an engaged and dedicated person or group of people who are willing to push the agenda [5.2.4, 5.3.3]. The final issue of implementation is that of an office or administrative body. Ideally, there would be a keen professor who would be willing to be involved. In the current academic environment in Canada, it is nearly impossible to convince a professor to get involved in a specific cause, unless he or she wants to do it.

I asked many interviewees about the merits of another administrative office at the university. The response varied from very supportive to very concerned, as indicated in the following three quotes.

JDJV: Do you think there is merit in ... a Humanitarian Engineering office?

Ca15: Yes. Yes. To urge them to do this. Just like we did to bring in gender issues. There were people appointed to look at gender issues. Why not issues of human need. And say to people, ‘have you in your curriculum brought this in?’ Or bring it in to the P and T.\(^\text{15}\)

If you make such an office, it will be underused by those who need it and

\(^{15}\text{Promotion and Tenure.}\)
overused by the zealots who have already diluted themselves beyond repair. You’ll either have people working in that office getting headaches because conservative professors on one hand and revolutionaries on the other, or there will be revolutionaries who are working in that office and will succeed at alienating everybody. (Ca13)

Ca14: There is a need to continuously remind professors that they should be [talking about environmental and social sustainability.]

JDJV: And who should be doing that?

Ca14: Maybe there should be a question on the USAT\textsuperscript{16} ... So, no. We don’t need more coordination. We don’t need an office filled with people pushing paper around to coordinate this. I’m not a supporter of building up these bureaucracies.

In the end, there will have to be one way or another to get past the administrative hurdles. Exactly how this is done will have to be carefully outlined. People, especially at the university, do not like being told how to do things. An organization can rarely force change, but the change often has to come from the bottom up. Thus, a leader or champion from within the institution must excite the students to create the engineering curriculum that they want, if this initiative is not already being seen. Regardless of what happens, if a humanitarian engineering program is undertaken, the tasks listed in Table 6.8 will have to be tackled.

The ideas presented in this section give a small view on what a Humanitarian Engineering program could look like. Actually carrying it out could look much different, although this section will provide a useful starting point.

Now that the research question has been thoroughly discussed, I am in position to ask ‘so what?’ and give some conclusions and recommendations. That is the purpose of the

\textsuperscript{16} University Survey of Student Assessment of Teaching.
Assist faculty to adjust curriculum  
Run workshops on engineering and human need  
Seek out partnerships for collaboration and placements  
Help with administration for placements — visas, tickets, housing, for example  
Organize seminars, find speakers  
Pre-departure training  
Post-placement orientation  
Facilitate conversations with other departments, International Centre

Table 6.8: Potential tasks of the Humanitarian Engineering Office

next and final chapter.
Chapter 7

Closing words

Any intelligent fool can make things bigger, more complex, and more violent. It takes a touch of genius — and a lot of courage — to move in the opposite direction. – EF Schumacher

To know and not to do is not to know. – ancient Chinese proverb

Human maturity comes as we begin to bring our heads and hearts together. – Jean Vanier

Concern for man and his fate must always form the chief interest of all technical endeavours. Never forget this in the midst of our diagrams and equations. – Albert Einstein

This thesis is about engineering education. Specifically, I have suggested that engineering students should learn more about marginalization, human need, impoverishment, and human development. Engineers play a crucial role in improving living standards throughout the world, but this must be done without the hubris that has plagued development work in the past. We do not live with the same optimism as the previous generation, nor
have we progressed to a better place promised through education or technology. Engineers must learn from the lessons of history to find a renewed sense of purpose in their work. Failure to learn from the history of technology and development is devastating, according to Smillie:

-One of the solutions to the poverty problem, an important one, is technology. Unfortunately, in the hands of governments, foreign engineers, experts, amateurs, bureaucrats, corporations and aid officials, the lessons of technology in history have been largely ignored. In the quest for sales and a search for the big breakthrough, they have colluded in one of the most expensive and tragic hoaxes of all time. [2]

Economic growth, aid, and large scale engineering development projects all have merit, but the results given in this dissertation suggest that human development and poverty reduction must be done at the community level with a human element. A community’s wisdom, tradition, and participation are paramount to sustainable development.

Before moving on, it is important to stress that the past 4 years of this thesis work have been a real personal journey. Conducting this research has required a constant scrutiny of myself as a researcher and of the research process. I was surprised at how much the reading and interviewing changed my thinking. Initially, I was excited about this project because of the opportunities to design appropriate technologies for needy international communities. While this excitement does still exist, I am much more leery; during the process I learned a lot about technology in society, the need to challenge structures, the need to work in one’s own community, and the dangers of international placements. The incredible privilege of travelling to Ghana showed me a lot about my own Canadian life that I often take for granted and much about another culture that I would like to emulate. This research has changed my career ambitions as well: I now feel strongly about seeking engineering solutions for the locally marginalized and investing in the community in
which I live.

7.1 Summary of the data

Before moving on to the conclusions, a brief summary of some of the relevant points raised by both Canadian and Ghanaian interviewees is presented.

- **The social role of engineering**
  - In the current globalized climate, there is an increasing social role for engineers.
  - The limitations of reductionist thinking are becoming more pronounced.
  - Technology is intimately connected to social issues; engineering must be done in a cultural context.
  - While the importance of engineering-service to the community is stressed in the professional literature, profit often takes priority over community needs.
  - There is a tension over the degree to which engineers need to have a social role: too much will dilute their skills.

- **Humanitarian engineering curriculum**
  - There is interest in humanitarian engineering ideals among students.
  - This curriculum could offer a very important awareness component.
  - There is room in the engineering curriculum to incorporate a larger social justice component.
  - Engineering needs to be more unified, multidisciplinary, interdisciplinary, context-driven, and problem-focused.
  - Engineering must seek to solve problems for people and not just governments or corporations.
– Humanitarian engineering will require some unlearning and deeper understanding of the global impact of engineering.

• A humanitarian engineering placement

– Engineering and development placements offer important benefits to students.
– Success of a placement depends greatly on the student’s approach, attitude, and cultural awareness.
– Service placements can cause more damage than help to a community.
– Cross-cultural experiences can inspire a lifetime of working with marginalized communities.
– Opportunities for local placements are not as obvious as those for international placements but are important because of the need.
– Both local and international placements can help put globalization into context.
– Local placements complement international placements.

• Addressing the root causes of marginalization

– Using technology to address the root causes of marginalization may require a broader view of technology.
– In many cases, an engineer can only address the surface issues, but that is still very important.
– Working for root causes does not necessarily require intervention.
– Humility and awareness are necessary steps towards addressing root causes.
– Engineering is political.
– Addressing the root causes is important for engaging enthusiastic youth.
7.2 Conclusions

I cannot conclude that there is a right way to educate engineers based on phenomenographic research. I can, however, give insights into ways of looking at specific concepts and thus make some informed suggestions and proposed directions.

There is a need and an opportunity to educate engineering students about their role in providing engineering solutions, awareness, education, and policy change for poverty reduction, disaster relief, and human development. The conclusions and recommendations about any sort of curriculum change must, however, weigh the benefits versus the limitations of such a curriculum change. A well designed curriculum will address the role of the engineer (Table 6.6) and capitalize on the benefits (Table 6.4), and it can overcome many of the limitations and liabilities (Table 6.5) — but to what extent can the limitations and liabilities be overcome?

The limitations can be broken down into two categories: those dealing with cross-cultural placements and those dealing with the curriculum itself. Many of the potential problems with the curriculum can simply be addressed with appropriate curriculum and dedicated teachers. While the placement would not be the only component of any humanitarian engineering program, it would be a critical part and the potential problems with cross-cultural engineering solutions are the most challenging. These liabilities also require good curriculum design to overcome the dangers of development work, but that is just a small part of the solution. History has shown that good intentions can quickly lead to negative outcomes.\footnote{An old Irish proverb states: The road to Hell is paved with good intentions.} How can we keep history from repeating itself? If one were to review development projects on a case-by-case basis, there have been many successes. However, on a macro-scale, engineering and development has been ‘one of the most expensive and tragic hoaxes of all time’ [2]. So, how is humanitarian engineering taught so
that intervention\(^2\) into a marginalized community is done successfully, yet carefully?

The data suggests that a good curriculum design will include teaching technical skills in conjunction with instruction regarding the following:

- social justice
- social location
- cultural awareness
- root causes of marginalization
- a broader understanding of technology
- unlearning many elements about the role of the engineer and the dominant ideology

Incorporating these concepts is the key for humanitarian engineering success, for both students interested in placements and for students who choose not to get involved with cross-cultural intervention.

Placements are a valuable pedagogical experience, and thus, despite the many concerns, I cannot advise against them. I have personally benefited a great deal from my experiences in Ghana, for example. Placements can also result in positive change, even with the potential for damage; Sichel reaches similar conclusions:

> It doesn’t seem right to reject the notion that international travel can help bring forth positive social change. But considering the colonial legacy and power imbalance that continues to hang over relations between North and South, travel should always be undertaken conscientiously. Travelling specifically with the aim of improving lives in the Majority World is an ever thornier endeavour, which, when not undertaken carefully, can sometimes do more harm than good. [194]

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\(^2\)Keep in mind that one possible outcome of a humanitarian engineering curriculum would be that an engineering graduate chooses to address roots causes of marginalization without cross-cultural intervention.
In the end, short term, cross-cultural experiences must be seen as a privilege and not as a sacrifice.

Local placements are necessary if international placements are to occur. Not only do they complement each other, but it is necessary to teach that we do not need to travel far to find marginalization. In addition, the reaction, according to Rahnema, to what is happening internationally is to reinforce a sense of community [63], and local placements help this engagement to occur.

Ultimately, humanitarian engineering is about creating positive change in students, institutions, and local and international communities. Creating real, tangible change challenges existing powers and will always be a struggle. Einstein acknowledges this struggle:

> We must not conceal from ourselves that no improvement in the present depressing situation is possible without a severe struggle; for the handful of those who are really determined to do something is minute in comparison with the mass of the lukewarm and the misguided. And those who have an interest in keeping the machinery ... going are a very powerful body; they will stop at nothing to make public opinion subservient to their murderous ends. [62]

But change is possible, and dedicated leaders are needed. There is a long history of people who are neither poor nor weak, who stand up for those who are. An appropriate engineering curriculum can bring more engineers into the discussion about the nature, extent, and forces of deprivation, which in turn could lead to strategies for change. Figure 7.1 gives a graphical representation of how a humanitarian engineering curriculum can be a part of this transformative process.

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3There are many stories of dedicated activists who work against the powerful ‘machine’ for positive change. In the late 18th century, a small group of Englishmen in slightly more than 50 years brought the British slave trade to an end, for example. This slave trade was the economic backbone of the world’s most powerful empire [201].
To conclude, a major adjustment in the engineering curriculum to address human development is appropriate, and this new curriculum should include both local and international placements. The following are some possible outcomes of this adjustment:

- Create awareness of and encourage dialogue about issues of engineering, human development, and social justice.

- Train and encourage engineers to work for the marginalized and against social inequalities, and to seek careers doing exactly that.

- Give hands-on experience within a marginalized community with the intention of creating a desire for lifelong engagement with such a community.

- Train reflexive engineers who keep asking how engineering can be used to improve relationships and to decrease suffering.
7.3 Recommendations

It is recommended that engineering curriculum be adjusted to include humanitarian engineering, as described in Section 6.6. However, it is acknowledged that these suggested changes cannot all occur at once, or might need to be adjusted in light of unforeseen developments. The main focus of the curriculum should not be on ‘helping’ others, but on awareness, not so much of global poverty, but of the forces that cause marginalization. In an intensely individualistic society, humanitarian engineering must focus on relationships and operate with community in mind.

7.3.1 Eleven premises

It is recommended that a humanitarian engineering curriculum and program be built around the following premises:

- Premise 1: Humanitarian Engineering is not a sub-discipline in itself but a philosophy that must infiltrate all engineering and must encourage work with other disciplines.

- Premise 2: Not all problems require technical solutions; technology can only go so far.

- Premise 3: The right answer is often difficult to determine, but sometimes it is the discussion that is critical.

- Premise 4: Awareness without action is meaningless, and action without awareness is dangerous.

- Premise 5: Technology and tools are cultural entities, just like music and dress.

- Premise 6: The goal cannot be to make the world more like us. Development must mean change for everyone.
• Premise 7: It is patronizing and dangerous to think that we know what is best when we do not understand a culture. Cross-cultural work requires deep commitment, immersion, flexibility, and humility, and must be seen as a privilege.

• Premise 8: While specialization is rewarded in society, many of our complex problems require multidisciplinary thinking.

• Premise 9: Many cultures are stuck in a difficult place where traditional ways are cherished, but the globalized world promises opportunity and wealth.

• Premise 10: We are better suited to address the marginalized in our own community, although it is always easier to see the needs of an outside populace.

• Premise 11: Educators and community leaders must channel the vast resources of volunteerism towards social change for a more just society.

7.3.2 The program name

The term Humanitarian Engineering has been used countless times in this thesis. ‘Humanitarian Engineering’ is the term that has been proposed by the Faculty of Applied Science and in the Civil Engineering Department at Queen’s University, and I wanted this work to reflect the name currently used at my institution in order to make sure that the work appeared relevant in the popular discourse. That being said, I am not convinced that it is the right name, although it has been difficult to come up with a better alternative.

The following are some of the weaknesses of the name:

• Lacks the idea of transformative change or a social justice aspect

• Carries connotations of only charity

• Very human centred

• Not a term that is going to relate to youth — poor marketability
Several interviewees commented on the name ‘Humanitarian Engineering’ at the beginning of their formal interview with me.

Why do you call the whole thing Humanitarian Engineering as opposed to Development Engineering? ... It doesn’t speak very well to me — it’s very patronizing and condescending. (Gh9)

You have to do something about the name. It’s very 1950s — very Bretton Woods. (Ca6)

It is recommended that the name be changed to better address the vision of the program. A brainstorming process has produced many options, but each name seems to have its weakness. The best option, in my opinion, is

**Engineering for Human Development and Social Justice.**

With this name, however, the program must promote social justice, as defined earlier in the thesis. The program will be offering a disservice if it does not provide what the name suggests, creating great confusion among the student body as they strive to find appropriate responses to social inequalities.

Regardless of the name, an engineering focus on impoverished and marginalized communities has a tremendous potential for transformative change and pedagogical richness. The success will come down to the attitude of both the students and the administration.

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4See Table H.1 in Appendix H
5This name could be perceived to suggest that human development does not incorporate social justice. While these two concepts are very connected, human development conjures thoughts of stronger community while social justice suggests a larger, global, and political realm. There are many good reasons to add Ecological Justice here as well. I have chosen to leave it out because social and ecological justice are so interconnected that you cannot have one without the other; social justice implies ecological justice. There is also merit in having a name that is not too long.
7.3.3 Concerns from interviewees

At the end of every interview, I asked the interviewee about her or his greatest concern regarding a potential humanitarian engineering program. The final recommendation of this dissertation is that the following concerns be carefully considered:

1. Placements are done safely.

   If I was involved in it I’d worry about placements being done properly and safely. It’s a good idea and if there is a demand for it, and if the numbers grow and it does good things and gets recognition for good things, well, that’s fantastic. (Ca14)

2. Program is truly people-centred.

   Personally, I am very encouraged by this idea. We need people who will look at engineering from a people’s perspective. We need it not to be looked at as a business, but as a service to people. It is easy to be swayed by the business part. (Ca15)

3. Program is not only a public relations campaign.

   Humanitarianism is being used as a public relations campaign. As much as I love to do it, it is in large part a way of servicing our large burden of guilt that we feel because of our privilege. And it is a way of serving our guilt instead of serving our desire to build a good life for all. There is something innately self-serving. It can blind you. (Ca10)

4. Program is designed with humility and contemplation.

   I see merit in pushing Humanitarian Engineering forward as long as it is implemented in an honest, realistic, and non-flakey manner. At every
stage the administrators of such a program have to sit themselves down and ask, ‘what are we doing?’, ‘what are the exact benefits of what we are doing?’, and ‘could it be achieved in a more efficient fashion?’ It is far too easy to slip down the slope of zealotry and you wind up producing students who are disillusioned, condescending, or patronizing. (pause) So, there is merit to it. The focus to it and the most beneficial aspect of it is the ingrained sense of humility in its participants. That is the single best thing that you can impart on a student. This does not mean that you have to send people to far away and exotic places. (Ca13)

5. Program is not self-serving.

Who gets to the table where what the needs are is decided? Who gets to the table in terms of the teachers who are structuring these things, a humanitarian engineering education, but also who gets to talk about what community needs are, both locally, nationally, and internationally? As relative outsiders to a community in Northern Ontario or Manitoba, we’ve been pretty willing to allow the usual suspects to speak on behalf of those communities. And strangely enough, what they want seems to dovetail quite nicely with what we want. ... Who is this community and who gets to speak on behalf of this community? The history of what’s been done to people and on behalf of people in the name of good works is checkered and part of the checkeredness comes from not listening. (Ca1)

7.4 Future work

At the end of many research projects, there are often more questions than answers, and this project is no exception. There is no shortage of ideas for future study:
• The successes and failures of other universities with engineering and development programs could be studied.

• The successes and failures of international engineering service learning projects could be studied.

• Development agencies such as International Red Cross, CARE, MSF, or Oxfam could be surveyed to understand the qualities that they look for in engineers.

• International engineering firms could be surveyed to understand how they view engineering and human development and how they feel the curriculum could be adjusted.

• Local, community development initiatives could be surveyed to understand their engineering needs.

• The appeal of a humanitarian engineering program could be studied by surveying a variety of high school demographics.

• The optimal social and political structural conditions for a humanitarian engineering program could be explored.

In the case of this project, however, the most important future work is to get humanitarian engineering ideas implemented. It will take time to adapt and reach balanced and optimal operating conditions, but the most important plan is to start incorporating something into the engineering curriculum. Hopefully, this study can be a catalyst for exactly that.
Bibliography


[90] Lewis Strauss. Speech to the National Association of Science Writers, New York City September 16th, 1954.


[96] Leah Jamieson. Will engineering graduates have the attributes and skills they will need for careers that will span the next 40 years? *DesignCon, Santa Clara, CA*, January 29 - February 1 2007.


Appendix A

Interviewee details

The following list highlights some information about each of the 32 interviewees. This information may be useful to put specific quotes into context.
## APPENDIX A. INTERVIEWEE DETAILS

<table>
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<tr>
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<th>Citizenship</th>
<th>Gender</th>
<th>Done dev. work?</th>
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Appendix B

Interview questions

The following document was used as an interview guide. I had a hard copy in front of me during every interview, although I used it less as I gained more experience. In some cases, of course, some of the questions were not relevant. I did not always ask the questions in order and I often rephrased them according to the dynamics of the conversation. This document was simply intended to be a guide.
Interview Guide

General/Introductory questions:
- Does the engineer have a role to play in helping others/the marginalised? What is this role?
- Does the engineering sector have an obligation to help?
- What sorts of skills are necessary for an engineer to work with a marginalized community (cross-culturally)?
- If you have had an engineering cross-cultural experience, what skills do you wish you had?
- Many people argue that the majority of the world’s problems are social and not technical. What is the role of technology in human development?
- Engineers are trained to be efficient problem solvers and thus, there is a risk that they will try to immediately “fix” problems. Does the development world need more engineers?

Humanitarian Engineering curriculum
- Should the idea of human development be in the curriculum?
- Can these ideas be placed into any engineering course? In which courses would it be difficult to incorporate humanitarian engineering ideas?
- Would inserting more appropriate examples into regular courses be an effective way of teaching about technology and development?
- How can development work make one a better engineer?

A potential placement.
- It has been proposed that interested students are given an opportunity to have a credited placement. Is this a good idea?
- Why do you think the idea of an international placement in engineering is so appealing?
- Do you have any examples of successful or unsuccessful engineering work that was accomplished cross-culturally?
- There is the danger of these becoming working vacations. How can this be prevented?
- Is 4 months a long enough time for a placement?
- Is a placement necessary for a program?
International versus local projects.
- In your mind, how important are local and national projects?
- What are some of the pros and cons of using designs from another culture when working with a marginalised community?
- What might a good placement look like?
- What might a bad placement look like?
- How do we get to the root of the problems?
- Do engineers have a role in social justice?
- Does it matter if the engineer cannot address the root causes?

Concluding questions.
- How has cross-cultural experience influenced your career as an engineer?
- What are the benefits of hiring a person with this sort of educational experience?
- What are your largest concerns?
- Is there a better name?
Appendix C

General Research Ethics Board

Review

The following two documents were given to the interviewee before the interview began. The Letter of Information was given first and once the interviewee had read it, she or he was given the Form of Consent to sign. I kept the signed consent forms. In some cases, the interviewee wanted a copy of the signed consent form as well. In those cases, we both kept a signed consent form.

Documents listed in this appendix:

- Letter of Information
- Form of Consent
Letter of Information

Project Title: Humanitarian engineering in the engineering curriculum
Principal Researcher: Jonathan VanderSteen, PhD Candidate, Queen’s University
(613) 533-6000 ext. 78489, jonathan@ce.queensu.ca

It has been proposed that the role of the engineer in poverty reduction, disaster relief, and human development be addressed in formal engineering education. This study is being conducted to investigate this role for the purpose of making appropriate changes to the engineering curriculum. This study will consist of interviews with engineering educators, students, potential employers, development agencies, and potential beneficiaries of such engineering projects. As a participant, you will be asked a series of questions related to engineering education, human development, and technology. The interview will be recorded with a digital audio recorder and will take less than 1 hour.

There is no known risk associated with your participation in this research. Your participation is completely voluntary and you may withdraw yourself and any or all of your statements from the interview at any time. You are not obliged to answer any questions that you find objectionable or that make you feel uncomfortable.

Your identity will be kept anonymous in all research material. The only individuals who will have access to your statements are researchers with scholarly interests at Queen’s University. Your confidentiality is guaranteed and your statements will not be connected to your name in any publication.

If you would like further information about the study, or have additional questions or concerns, please feel free to contact me. Your may also contact my thesis supervisor and Head of the Department of Civil Engineering at Queen’s University, Dr. Kevin Hall (613) 533-2127, or the Chair of the Queen’s University General Research Ethics Board, Dr. Joan Stevenson, (613) 533-6000 ext. 74579.

Yours Sincerely,
Jonathan VanderSteen
Personal Consent Form

**Project Title:** Humanitarian engineering in the engineering curriculum

**Principal Researcher:** Jonathan VanderSteen, PhD Candidate, Queen’s University

I have read and retained the Letter of Information that outlines the purpose of this research and my participation in the project. At this time, I have also had all of my questions answered to my satisfaction.

I am willing to participate in this research project and I understand that:

- My participation consists of a one-time interview by Jonathan VanderSteen. This interview will last between 30 minutes to an hour and the audio may be recorded.
- My participation is voluntary and I am free to withdraw at any time at which point any recorded data will be destroyed, if I desire it.
- My identity will be kept anonymous in all research material.
- I am not obliged to answer any questions that I find objectionable or that make me feel uncomfortable.
- I will not benefit directly from participation in this research.
- If I have any questions or concerns related to this study and its procedure, I can contact any of the following individuals for further information:
  - Jonathan VanderSteen, Principal Researcher, PhD Candidate, Department of Civil Engineering, Queen’s University, (613) 533-6000 ext. 78489, jonathan@ce.queensu.ca.
  - Dr. Kevin Hall, Thesis supervisor, Professor and Head, Department of Civil Engineering, Queen’s University, (613) 533-2127, hallk@ce.queensu.ca.
- If I have any questions or concerns about the ethics of this study, I can contact:
  - Dr. Joan Stevenson, Chair of the General Research Ethics Board, Queen’s University, (613) 533-6000 ext. 36288, stevensj@post.queensu.ca.

Name: ___________________________________________ Date: _______________________

Signature: __________________________________________________________________________
The interview may be audio recorded confidentially and for research purposes only. A select amount of recorded information will be transcribed.

☐ I agree to this interview being recorded on a digital audio recorder.
☐ I do not agree to this interview being recorded on an audio recorder.
☐ I grant permission to be quoted.
☐ I do not grant permission to be quoted.

I understand that there is no known risk associated with my participation in this research.

Name: __________________________________________ Date: ______________________

Signature: __________________________________________
Appendix D

Humanitarian Engineering Discussion Group

Topics or research papers discussed at the biweekly Humanitarian Engineering Discussion Group are listed below. This discussion group is an open forum for professors, grad students and undergraduate students interested in engineering, education, humanitarianism, social justice, development, or policy. The format of the meeting has evolved over the years, but the general philosophy has remained the same. Initially I led all of the discussions, but now a variety of participants take turns leading.


11. February 1, 2007 — *Where are we going? Peace Engineering* by Aarne Vesilind and *EWB and Their Role in Humanitarian Relief* by Claes Helgesson.


17. April 26, 2007 — Two responses to the social role of technology — *Natural Capitalism* by Paul Hawken and *Gaviotas* by Alan Weisman.


29. May 8, 2008 — Humanitarian Engineering projects at Queen’s.


Appendix E

Transcribed interview

This appendix contains two semi-transcribed interviews. They contain some transcribed elements of the interviews and some point form notes taken while listening to the recordings. Interviews Ca4 and Gh9 are listed.
APPENDIX E. TRANSCRIBED INTERVIEW

Interview 8 - Interview code: Ca4 (Old code is 8O3)
Non-engineer, development studies student, QPID member, 4th year student, female, has been on several overseas projects

February 8, 2007, 10:12 a.m. (This interview was done in two parts because of an interruption)

0:48  JDJV: Is the engineer responsible for their own design?
I would say they should be, yes.
-design and technology - influenced by society
-Engineer is responsible for impact of design

1:15 "design is influenced by own social view and own position" And it is important to be aware of that

Design is influenced by one’s own social view and social position and it is important to be aware of that. I think you need to maintain responsibility with what you are designing. I guess there is a lot of talk that technology is neutral, but I don’t believe that. I think that technology is very political thing and it is important to remain aware of that.

I think a lot of times people aren’t aware of the way their own biases play into something and I think it is important to at least remain aware of that.

-Bias will alway play into design - how and what
-2:30 Engineering Competancy
-Not a diluting of knowledge
-It should be complementary
-Don’t want to overshadow technical training

JDJV: Can we teach engineers to be capable in their social role and to remain technically competent?
I don’t think it has to be a diluting of technical knowledge. I think it should be complementary. I don’t think engineers a lot of times think about it at all. Even if they are thinking about it a little bit, that’s a good thing. Like obviously, you don’t want to completely overshadow their technical training with social awareness.

***Engineering Curriculum:

3:10 Sometimes all it takes is one course to change the attitude in a whole faculty. But we must make this one course to be taken seriously by everyone.
-But one course - has been available for a long time - How do we get this one course to be taken seriously.
-curriculum - treat ethics course seriously

-can we use word obligation?
4:00 Obligation? To society. Legal, moral?
-An academic has an obligation to be an activist - reveal the truth
-should be concerned with social justice and inequality
Technology could take a role in that kind of stuff.
We have an obligation to teach engineering students and to expose the truth. In a way academics must be activists.
-People respond to that word - obligation
-need to be accountable for something

5:45 Social impact of technology
-Design projects - Reports must include social impact. Part of the design process is social constraints. Do a social impact assessment after design.
- comment on social impacts in a set of conditions

6:44
JDJV: Should discussion on human development and poverty reduction be included in the engineering curriculum?
803: I think it should be included. Yes. But it is a slippery slope to say that technology is a solution to all of their problems and I feel like that may be the way some engineers would maybe take that so I feel like that would need to be addressed: where technology fits into the broader picture of development.
- Should be included yes.
- Very difficult to say that technology is the solution to all of their problems
- Must address how technology fits into solutions

7:51 Why do we need engineers?

JDJV: If technology can't always be the solution, what is the role of the engineer? I think technology is part of the solution. I think it absolutely can. I think the reason that it often isn't part of the solution is that it is caught up in other interests so it is not necessarily going where it is needed the most.

-money
Can you give an example?
- pharmaceutical research. Who is it benefiting. MRI machines. Available for the poor?
8:09 - Technology can be part of the solution
- Problem is that it is often used to solve other interests - the corporation
- Not bad in itself

Engineers need to talk about human development and poverty, but it is difficult because we tend to want to talk about technology as a solution to all of the problems. Must address how technology fits into solutions.

9:11 - The university is less supported into corporate interests
- More for the common good
- Important to encourage it at the university level.
- I think the university is less tied up in these interests. Supported by public funds. Can be used to support common goods. More so that corporate research and development can.
- Government has their own interests. Then NGOs. Is the university even more neutral?

Technology can be part of the solution, but the problem is that often technology is used to serve the interests of governments, corporations and others, so it is not necessarily going where it is needed the most. The university should be less supported by corporate interests, and less tied up in corporate interests and is more for common good. Although it is acknowledged that the university is not that neutral.

*** International (and some local):

10:23 International?
"Development has to be framed as something that has to be done here, before taking it elsewhere."

- Our role? Intrude? Technology is a cultural issues. We're not going and trying to suggest what kind of music they should be listening to?

12:01 On the other side of the coin, We have already introduced technology into the most of the world. And it is not necessarily the technology that should have been introduced. And by in large, they want it. Unfortunately a lot of the indigenous knowledge has been lost, or even the natural resource base that supported that research
base has been lost. It would be irresponsible to abandon them completely, but we need to make sure it is on their terms.

-Foolish to abandon indigenous knowledge completely - but there must be some dialog and it must be done on their terms.

13:08 Danger - who is taking the controlling side of the dialog?
The danger is in who is taking the controlling side of the dialog.

13:24 Concerned about imbalance? Technology COULD take a role. Engineering educators can take a dialog.
Driven by rich country (business) interest. Technologies aren't developed for them. Most of them are driven for us.

14:52 Person experience (Ecuador) - They do want our technology. They probably don't want the appropriate technology. Not Appropriate Technology - Ecuador - Had DVD players and no shoes

"Where I was it was very poor and everyone had a cell phone. And most families had DVD players and their kids had no shoes. And they really wanted their DVD players. It was hard for me to say you don't need a DVD player, you need clean water. I guess it is a balance because we have gone overseas and now can we really stop."

***Placement:

15:38 Send students overseas? Educate them first. What do you think?
-I think it is obviously for the benefit for the student - enormous.
-There is obviously a huge danger for the community
-Can't do a whole lot in 4 months
-It is a difficult balance between Educational opportunity and potential for harm.

16:22 I think that it is obvious for the benefit of the student and not the benefit of the community. I think there is an enormous benefit to the student for going over and an enormous amount of awareness and a deeper understanding that comes from doing that kind of a placement. But there is obviously a danger in using a community as a learning tool. Do you know what I mean? There's a horrible power relationship in that. I mean, what are you really going to do in four months. Not a whole lot. ... It is very much a balance in how much you can justify the educational opportunity with the detrimental impact on the community.

JDJV: So if I were to stop you now and hand you a ballot and ask you to vote 'yes' or 'no' to the placement. Would you be able to do that?
I would say (pause) yes. Development studies has a placement program. First of all it attracts people to the program. You can read about this all you want, but there is a difference to see how people actually live their lives and it can be done in a way where it is not detrimental, but it has to be very carefully planned. And I think it has a lot to do with the individual student too --- in terms of how they view their relationship with the community.

JDJV: So what are the top skill necessary to ensure the minimal damage? ... Who do you send and how do you know?
I don't know if you can know unfortunately. I guess it would be someone who was aware of what their role is and also someone who was aware that the placement was for them and that they won't be a great savour of the community.

18:45 Important skills - someone who is aware of their social role and understands that the trip is for the student. Not to help.
-Can't just send anybody. But can you really know who is good? Not easily.

End of tape - interview was interrupted

New tape - counter has been reset.
APPENDIX E. TRANSCRIBED INTERVIEW

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- summary - a placement can be useful

0:24 JDJV: Expense of placement? Privilege.
The expense should be a real concern. Absolutely. And how much carbon emissions are you emitting. And where is that money coming from? Why do you have $2000 to get a ticket to Africa? Because your dad works for a mining company that is exploiting people in Africa. I don't know. It's a big issue. Unfortunately, it is not as if that money is either going to go for my trip or that it would go to farmers in Latin America. That's not a realistic choice. It's usually, I'm going to go to Ghana or buy a new TV. I'm not saying that's right --- it's the reality of it.

***Root cause of inequality

2:05 Can engineering help with root cause? If we're not fighting root cause - business as usual.
- Better off using efforts against root cause or symptoms?
- Again a balance
  - to address without address root causes - just part of the problem
  - But right now there is suffering

I hold the position that the root causes in a lot of cases is first world exploitation of the third world. Technology can not really address that. Technology can only address the symptoms of that power relationship and unfortunately I don't think any kind of revolution in the way the first world deals with the third world is eminent. In the mean time, technology can address those symptoms.

JDJV: Does that mean the engineer can't be a little force against some of these root causes?
I guess it is a balance. To address the symptoms without addressing the larger cause, you are kind of legitimizing the system and the status quo. ... If we kind of stopped addressing symptoms that that would cause enough of an uproar somewhere that things would change. I guess it probably would, but I don't know if that is going to happen on a large enough scale that it would actually happen.

5:24 Where has technology been used in a good way in development?
- unfortunately I've read very few development projects that have been successful
- Say the rice machine works and there is extra time or money - it still disrupts the social system. Is this successful? Cost outweighs the benefits.
  - Corn dehusker - social event is lost.
  - Extra time just gets filled up with other things - not liberated (Western similarly - washing machine.)
  - Do best not to uproot social situation. Is this possible?

Depends on the goals. Give women more power - a feminist goal? What are objectives? Disrupt power balance in the family and the social system

Unfortunately, I've read very few development projects that have been deemed successful, in four years. It is kind of sad, but unfortunately, that's the truth. Even if you achieve your objectives, say you give a rice dehuller to women and they do make extra income.
- upset power balance, family

Even if the technology is doing what it is supposed to be doing and achieving impact, the disruption in the social system might out weigh benefits of the technology. And it is almost inevitable when implementing technology, especially if it is dramatically different than anything that they have used before.

8:20 Try your best not to uproot any accepted social system
- Funds are equitably transmitted
- Are the goals to change the family structure?

9:05 At a conference - Goals - maybe one day the children may not have to work in the fields with their parents. Have schoolmaster decide what info to pass on to parents. - very questionable.
- What can a good technology be? One that has been developed within a culture.

9:58 A good technology is one that is developed within their culture.

- Have an incomplete design - see how they naturally adopt it - a bottom up collaboration

10:09 Maybe one opportunity would be to introduce an incomplete design

12:00 Aid versus resource drain and debt payments. Are we not just kidding ourselves in thinking that we can help?

- Can we stop the resource drain? If not, would it be best to stop aid. Don't know.

- Development - end exploiting.

- What really needs to happen is to change the inequality.

- We bring ourselves down, They bring themselves up.

13:45 Can this be done with policy? Playing around in Canada. Is this what engineers can do?

- Engineers have a good idea about resource extraction

- How can engineers work with policy

14:42 I think we can talk to engineers about influencing policy. I think it would put their role into perspective a little bit more.

- In education - talk to students not as engineers, but as people.

- Broader things have to happen.

***Local placements:

15:45 A placement in Kingston

- The issues are here just as much as they are elsewhere

15:59 National engineering projects are easy - aboriginal population

- Design low income housing for Canadian (if you can do it for 3rd world)

- Sustainable technologies is important (decrease our resource appetite)

I think the issues are here, just as much as they are anywhere else?

- Note: This is a very good interview, but gets a little bit weak at the end. (Broad discussion, personal thoughts on making sense of world)

***Conclusions:

18:33 Hope? Feel very implicated in all of this. I have a responsibility to do my best to change that. Remove my implication.

It is difficult - ie CPP investments are questionable - terrible implication

- eventually - system - working for a very small minority of people. It will eventually have to change.

In the mean time - work in whatever small ways

20: 55 "The best thing we can do is how we live our day to day lives. Consume less and more responsibility. In the end this is part of the solution."

- There are only so many things that policy can do. Government has their own interest. Weak democracy. Leadership from the people.

- Build strong community - maintain awareness of relationships and interconnectedness

- Simple life

- If you are going to go overseas - invest into that community

- The community doesn't have to be overseas
There is some merit in what we do? Absolutely

23:35  -Interdisciplinary - contact with social science - frustrating for engineers - not an answer
       -More broad education -Identify social location

I think new courses would be beneficial. I think what would be even more beneficial would be to get awareness of these issues integrated into the other material so that it is something that people are constantly thinking about. And it's not something only people with a prior interest in social justice or a prior interest in development issues to come to. That way it will at least possibly reach a broader community because otherwise it is preaching to the converted and I think you need to branch out to other people. But getting it integrated into the rest of the curriculum is certainly a bigger challenge, but that is the best way.

24:40 -Humanitarian Office - to reach every student
       -finding a balance

25:50 I'm really big on interdisciplinary. Even bringing engineers into contact with social science students. I think there is a big value in that. We're trained to think differently. I don't expect to find answer to my problems which I think engineers find really frustrating. 'What's the answer?' 'Well, I don't know.'
       -engineering design versus engineering analysis

26:45 I think bringing opportunities for that sort of dialog between people who do think differently, and make people aware of it. ... There isn't a blanket solution, necessarily.

*******************************************************************************
Why do you call the whole thing Humanitarian Engineering as opposed to Development Engineering?

1:38 It didn't speak very well to me. Very patronizing and condescending.

JDJV: Does the engineering profession and do engineers have a role to play to perform duties related to human development and social equity?

4:20 Engineers certainly have a role to play. Human development - yes. Social Equity or social justice - that starts to get into the political realm and even though whatever engineers do, whatever anyone does for that matter, has an impact on the politics and I hesitate to put it so categorically.

4:53 I think the engineers role is to contribute very much towards general development of society, towards progress in all spheres of social and economic life. I think that very much is the role of the engineer. I lament, myself, that we are not doing better at that here in this part of the world, than maybe you might be doing in your part of the world, maybe, I don't know. Things seem to be working better there. But I lament the ability to make a more direct impact on the social well being of our people. So, I emphasize very much with the thrust of your thesis. It is something that I believe in very much. And I think engineers have a strong role to play and can play if we take our task seriously.

-Two schools of thought - one of reductionist, one of importance of relationship between technical and social

JDJV: How do you respond to the school of thought where the engineer must be focused on the technical and the social stuff is left for others? How do you address those people?

6:40 I ask those people to delve a little bit into the history of engineering. ... But the little things that I have picked up here or there suggest that the engineer is always concerned with practical things. They are involved with doing practical things to improve their lives. Everything that I've seen, from the history of the car, and the engine, the steam engine, and the water pump, communication --- it has always been done to make life easier and effective for people. And I think that as your societies have become more industrialized and more segmented --- engineering versus social science versus political science and so on. In the societies where we have a lot more, it is a bourgeois view to say that engineers should worry about innovation and mathematics and the science and the physics and leave the applications to social scientists. I find that it is a very bourgeois view because then, it makes engineering very stale and those who come to engineering in this part of the world want to solve practical problems and they are terribly disappointed when they come into here and are inundated with calculus and Laplace Transforms and all these kinds of stuff.

JDJV: It gets a bit empty at times.

8:15 It gets completely empty. I keep hearing it from the students. I complained in my own time. I think it is an attitude of a more industrialized society.

-engineering history
-end in itself - product before the market., money before a use.

JDJV: Why is engineering education lacking in these necessary social issues?

9:45 I tend to answer that question by look at two angles of developing society. I could be wrong on the developed side. (laugh) I could be wrong on the developing side too. On the developed side, I think as the basic problems have been solved and engineering has had to deal with more technically intensive, scientific challenges. I think it has spawned this belief that there are other people who will deal with the social welfare, so `let them get more
specialized.’ ... Now unfortunately for us on this other side, the majority of our engineering has been formed in your traditions, in the traditions of the developed countries. And in my view, they have not critically transferred it here and it is not really appropriate for our environment. Because we still have very very basic problems to solve — the majority of which don’t need half of the sophistication of things which your guys are dealing with. Your guys are developing a space arm. That was twenty years ago that I was in Canada and so you need your mechanism theories and so on. What are we dealing with here? We’re dealing with gutters and sewer systems and water that doesn’t flow and basic piping networks. We don’t need half as many Laplace transforms to solve those.

11:45 So I think it is an uncritical transfer of systems thinking out in your society that is breeding that here as well and I think that if we aim to make engineering (fade away) And this doesn’t just pertain to engineering --- economics. We have people studying economics who don’t even know what the GDP of Ghana is and they don’t know what the foreign exchange earnings are for this or for that, but they are studying economics and are passing their exams and going ahead. So the formal sciences and formal education has become so very divorced from real life --- much more so in our society, unfortunately. we who need it more.

- Studied 2 years in Canada
- Candu Reactors
- In Canada - do we see the same trend
  - Is engineering more in tune to the needs of the community?

JDJV: What changes would you make to your curriculum?

14:10 For a start, I would make it a lot more practical. I would immerse it more in the industry around us, whatever state it was in. There is also much poverty around us that I would immerse it in. Now the industry around us, like Suame magazine, with all of the fitting shops and all of the welding shops and I would want to immerse some part of the curriculum in those sorts of problems of those local industrial establishments.

15:05 So beefing up the practical component would be one component.

- Connect the classroom to what is happening outside of the classroom in the city.
  - With a very mechanical bias, industry, small scale manufacturing

15:42 I would want to see agricultural engineering more in tune to farmers and cooperative.

Civil Engineering contractors in this country don’t care about our city infrastructure.

- Back to Canada - connections to the most marginalized

JDJV: Can you think of ways the engineering curriculum can be used to teach students of their potential role in helping the most marginalized?

17:15 I think exposure and direct observation would be a starting point. I think that would be a big part. You can go to University in Canada and not see one poor person. You just see the glitz of the big city and don’t see anyone who is marginalised. It is easy to go to the big industries and think that that is all there is. In your environment, if I’m right, the marginalised tend to be in the minority, so you have to make a bigger effort to expose students to the conditions of the marginalised. ... Getting them thinking would be a good start.

JDJV: In your opinion, is that worth the time commitment when considering all of the things than engineering students should be faced with?

18:46 I’m being selfish here when I say yes. Because if they can solve the problems of marginalized people in society, they will then be able to focus on us. (laugh) Whether it is a worthwhile investment in your economy, in your society, from a moralistic standpoint, I would say yes, but from an economic standpoint, I might say no. These guys are paying school fees and they want to be getting employment when they graduate, so they don’t want to be wasting their time on some marginalized people who aren’t going to employ them and who aren’t going to be a return on their investment. So there is a double sided issue there.
APPENDIX E. TRANSCRIBED INTERVIEW

JDJV: What do you think of sending an engineering student to a marginalized community in Canada or Ghana, to learn, interact, and maybe help? Any gut reactions when I talk about that? Is it a good idea?

21:39 The gut reaction, and again, from a selfish standpoint --- I want us to mop up as much help as we can get from as many different corners as possible. I have a natural inclination to Canadian students coming into our part of the world, because whatever you see in a marginalized community in Canada, you will see a thousand-fold in Ghana. So in that sense, even from a value for your money perspective, and from my selfish perspective where I'd like to see people think about our problems, then they should come here.

There would be value for your students in knowing that these problems do exist inside of Canada and right next door. I think it is part of the integral education, if you like, that students don't see a warped sense of the world, so in that view, I see value in exposing them to marginalized communities in Canada.

Otherwise, I would want them to come here. They will see so much more and probably make a bigger contribution. Probably --- I'm not entirely sure about that. Certainly they would see much more here than they would in Canada.

-Any problems?
-4 or 8 months
-Is it worth the expense?

24:00 I have been associated with Engineers Without Borders. They send some very good guys here.

We talk about the EWB people that we know. They did a great job here. They were great ambassadors for Canada. I had one of my own students here work alongside one of those guys and it was such a great learning experience for him as well to see another engineer from a different environment and do so much.

They do some very good work in coming here and I believe that it has influenced them for life. I'm tempted to go back to your earlier question and suggest that if students in Canada came to developing countries, like here, they probably would be fired up enough to tackle some of the marginalized problems in Canada. Originally, they may have their own conceptions on why people are marginalized in Canada and I don't think they will have as much empathy as they would if they saw marginalization here. It would be interesting to find out how these EWB guys are doing.

25:55 So, yes, I think there is value in the international placement for us as well as the students who come. And that is something that I would like to see more of.

-a real educational experience
-learn so much about another culture
-a great expense - financially, risk

JDJV: There's no doubt that it will be great for the student, but will it benefit the community in which they will work? Is this just one more thing that the west is taking out of Africa: an exciting experience?

27:00 That is an interesting way of looking at it. For so long as it doesn't contribute to an improvement in the living conditions of the developing country people, the Africans, then I guess, yes. But if it does contribute to improvement in the living conditions, then I say it is worth it. Even if it is something that the West is taking out of Africa, if it is contributing to an improvement in life, then it is worth it. Now, this isn't going to be the
first time there is placements, so do international placements contribute to life in the developing world, that's a big question. That's a big question.

amazing experience for the student  
can go terribly wrong

28:10 I can well imagine that there are communities that can have their, (what's the word), their colonial mentality re-enforced with the coming of interns. I talked about these EWB guys. They came and they did so much work. It is possible that the people think that these white guys are so much better than our black guys who don't do anything and they reinforce stereotypes and so on. It has to be properly organized.

unhealthy views of the west in Ghana  
inferiority complex  
that's true

29:45 Root causes of poverty - political issues, exploitation

JDIV: Can we as engineering educators deal with some more of these political, root cause issues?

30:20 More and more on the Africa, developing world side, we are blaming ourselves. There will always be a rich world, so if the root cause of poverty is the rich exploiting the poor, well, you aren't going to change that. There will always be politicians and ruled people. More and more we are blaming ourselves because we think it is our attitude that is keeping us poor people, keeping us as underdeveloped societies and therefore we have to find ways of changing our attitudes: attitude to work, attitude to life, attitude to time, attitude to lots of things. So, for many of us that has become a number 1 priority. We've talked about placements --- people like me advocate for our people to get outside, into your countries, and learn in those environments. Just like you learn so much here, give them a chance to learn in the other direction and learn some of the values that make your societies what they are. You can debate that too --- I'm sure there are lots of people who would want to debate that. So, yes, the attitudes are becoming very important, and we must find ways of tackling those.

32:00 The politics, we, those of us in this school of thought tend to think that the politics is a reflection or a symptom of the base attitudes of the people. If you have people who's base attitude towards authority is one of reverence, then politicians will continue to exploit them. So, what am I going to do about the politics, really, as far as engineering is concerned? As far as anything is concerned, let alone engineering. I would focus engineers on getting a more 'can do' spirit. A more interventionist attitude as far as social attitudes around them are concerned and hopefully that will translate into the politics and economics around them.

If the people lead, the leaders will follow.

If the people lead, the leaders will following. It is a nice idea, but not easy to implement. It is a lot easier if there are a few politicians who lead the way to change society.

33:30 We train engineers here and a good number of engineers that we produce here, don't think that they can do anything.

award ceremonies in the US - black engineers - wanted to make things  
people want to make things  
very few of the Ghanaian engineers would say that they wanted to make things.

34:00 Very few of our students would say that they came into engineering because they wanted to make things. And fewer would say so by the time they left. By the time they are leaving, they are so screwed up, they don't think they can do anything. They think that making new things is a white magic --- for the white man. We don't have much so we can't do much. And I think a big challenge for us is changing engineers and showing them that they can do a lot and that there is a lot to do.
if they are doing some real practical things - they will see some results.

35:30 Big picture, and implementation

36:20 First of all, I would be careful not to over do it. I can imagine myself as a student in Canada and every course go to, to be bombarded with the situation of the marginalised and I can get put off.

The second point is that I would, and I think that your universities are already doing this, I would increase electives. I would make sure that there are some courses that expose students to more global economy and global politics and have a few more of those courses stream in there, but I wouldn’t make those a majority. But I know that the majority of people who study engineering don’t go in to study these things. So, if you pump too much down their throats, there can be a reaction.

I’d also like to see a bit more of historic type things. And maybe you can do more of that in some courses, but I wouldn’t do it in all courses.

- forcing ideas
- engineering and industrialization
- Computational heat transfer - What does this have to do with marginalized

41:45 Courses on appropriate technology
- Multifunction platform
- Cookstoves

JDJV: What is your opinion on us offering a course on appropriate technology as say a fourth year elective?

42:20 I’m one of those who cringes when I hear the word appropriate technology because it is used to put us in a second rate technology mindset.

43:15 I think that you could have, one or two courses that introduce your students to that side of engineering --- that we have engineers out there and that is what they worry about. ... I think that is a useful thing to do, but I imagine in your type of curricula that it would be a very small type thing that you do so that students know that that also exists. And I would be careful to do it in ways that do not reinforce the view that that is second rate engineering.

- later revisits this idea - if students want something more meaningful, then more should be available

Humanitarian - does not capture enough of the transformative changes.

Final comments
- a real need to look at developing country curricula

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Appendix F

Field report from Ghana: Summer 2007

This appendix contains a field report that I prepared upon return from Ghana.
Humanitarian Engineering in the Engineering Curriculum

Summer 2007: Field Research in Ghana
Reflection on Technology and Development in Ghana
by J.D.J. VanderSteen, PhD Candidate

Introduction:
Between May 22, 2007 and August 15, 2007, I lived, travelled, and conducted my PhD research in Ghana. I am attempting to answer the following research questions: Is there a need or an opportunity to educate engineering students about their potential role in poverty reduction, disaster relief and human development during their formal engineering education? What is this role? What would be the benefits and the limitations of such a change to the engineering curriculum?

The purpose of the trip was to collect data primarily through interviews and field notes. I interacted with many engineers and engineering students, as well as development agents and benefactors. The interview questions focused on the role of the engineer, the required skills of engineers working on human development projects, the benefits and limitations of development projects, and the role of technology.

This document is intended to summarize thoughts and finding from the past 3 month while I was in Ghana. The comments are based on reactions and do not represent any in depth analysis of the interview data.

Schedule:
Week 1: May 21 – 26. Travel to Ghana. Spent some time in Accra to get acclimatized. Met with several engineers through connection with the Institute of Local Government Studies. Travelled to Kumasi and settled into the Spring Hostel at KNUST.

Week 2: May 27 - June 2. Orientation with KNUST and started teaching at Kumasi Polytechnic. Set up initial interviews. Met with both engineering and development students.

Week 3: June 3 – 9. Trip to Tamale and Bimbilla with a Ghanaian/American team doing a water project. Spoke with folks from the Jimmy Carter Center.
Week 4: June 10 – 16. Interviews with several important engineering professors and graduate students. Met with Heads from Mechanical and Civil Engineering.

Week 5: June 17 – 23. Connected with KITE - a very important energy NGO. Continued work at KNUST and in Kumasi.


Week 7: July 1 – 7. A week in Gomoa Dago. Participated in a development project in this little fishing town.


Week 9: July 15 – 21. Started making transition from engineers at the university to engineers in the community.

Week 10: July 22 – 28. Met several times with Care International and got involved with their project at the Coke Plant (Ahinsan). Visited several professional engineers and NGOs in Kumasi.


Week 12: August 5 – 11. Spent first half of week wrapping everything up in Kumasi. Headed to the coast for approximately 1 week.

Week 13: August 12 – 18. Final days in Ghana. Spent some time in Accra - mix of work and travel.

**Interviews:**
My 3 months in Africa gave me many opportunities for discussions. I took notes after many of these discussions and may include some of the lessons learned in my
thesis as field notes. I will consider 15 of my conversations as full interviews, although I did not record the audio for all 15 of them.

**Development Projects:**

I was also able to participate in several development projects. These gave me a valuable perspective on the development industry and on poverty, engineering, and development in Ghana, a low-income country.

1. Rural Water - Bimbilla
2. Rural Development - Gomoa Dago
3. Urban Water and Sanitation - Kumasi (Ahinsan)

**A note on Methodology:**

I have previously written a substantial amount on my methodology. I found that during my time in Ghana, I chose to stray from my original plan at times. First of all, it was not always practical to have a formal interview, complete with the signing of a consent form and the use of my digital audio recorder. Secondly, a lot of really interesting ideas and thoughts were expressed in hundreds of short, informal conversations with students, professors, NGO workers, and even fellow tro-tro passengers. I took many notes everyday and plan to include many of these ideas in my thesis as field notes. I did have some field notes from my research in Canada, but not nearly as many.

In some cases, I conducted a more formal interview, but I did not record it, again because it was not practical. In these cases I took as many notes as possible, both during and after the interview. In other cases, I interviewed two engineers at the same time. I even interviewed a busy engineer as she was having her nails done and having her feet soaking in a mini jet spa.

An interesting result from my research in Ghana is that I did not receive the same breadth of variation in the responses. I believe this is due in part to the nature of Ghanaian culture and also due to the limitations in my skill as an interviewer. It is common for Ghanaians to not voice their true opinion, but to voice a popular opinion or to share the thoughts of a prominent person. Western culture tends to be more individualistic and African culture still has some deep roots in communal living. In one interview, for example, the interviewee told me that he would never contradict his supervisor's opinion. In fear that this person would want to say what
he thought I wanted to hear, (since I was doing research on Humanitarian Engineering, I obviously thought it was a good thing) I tried very hard to extract the interviewee's true feelings by repeating some of my questions in a variety of ways. It was even more important in Ghana, than in Canada, to be careful not to offer my own opinion in fear of directing my interviewee.

Ghanaians, in general, do not want to offend and I felt at times answered my questions with the intention of encouraging me and I don't know if I always got the true answer. Everyone, for example, thought the idea of Humanitarian Engineering placement was a good idea. In subsequent questioning, several people did express some concerns, but the initial enthusiasm was sometimes suspect.

Later in this document, I will write about the relationship between the Ghanaian and the foreigner. In my case, I had an uncommon relationship as the interviewer and a foreigner. Culturally there are many complex things to understand as a Ghanaian interacts in a foreigner, and I was really surprised that there were not more Ghanaians who did not want the white people around given the history of slavery and colonialism. In fact, in the three months I was in Ghana, I only had one person who was hostile towards me because of my skin colour: "White man, go home" he continually repeated. This relationship is also necessary to understand in order to make sense of my data. Were some folks unwilling to be critical of my work or to contradict what they thought I believed, even if they felt otherwise?

**Engineers in Ghana:**

The engineering profession is very highly respected in Ghana. Engineers can often be seen wearing neat and well ironed clothes and polished shoes. Engineers are viewed as important people for the health of the country and are given much respect. They represent development and progress and are a symbol of intelligence and higher education. There is a lot of discussion in many circles, especially the media, about moving forward and development, and science and engineering are seen to be at the corner-stone of this advancement.

Ironically, many students who are trained as engineers do not want to work in the field. Many of them go into the field knowing very little about it. They go into engineering because of the prestige and wage earning potential, or simply at the
advice of a mentor, based on that student’s math and science skills, and are disappointed once they get a better idea of the field. Some students claim that the task of cranking out calculations was not what they were interested in and others see more opportunities in the business or banking sectors. In an informal survey, a recent Mechanical Engineering graduate from KNUST found out that 42 out of 52 of his graduating class were not working as engineers, but were going into business, banking, or working towards an MBA.

Some engineering graduates try to use their engineering degree as a ticket to a Western country, although these opportunities are getting more difficult to find.

Most of the engineering graduates who decide to stay in the engineering field and stay in Ghana end up working for the federal, regional, or municipal government, a foreign multinational corporation, or an NGO. Several students I talked to suggested that there was not a tremendous amount of variation in opportunities, especially since the recent power crisis was limiting the profits of many companies doing business in Ghana.

There are some opportunities to work with local entrepreneurs or to start a company, but this requires a lot of risk. One professor I spoke to on this issue said that “Ghanaians are imitators, not innovators” and that your average young engineering graduate doesn't want to get dirty. A student that I met who was working with a local food processing machine manufacturer told me that he was happy with his work even though it was hot and dirty. He said that he had no desire to work for a large multinational corporation where he’d be powerless and voiceless. This student seemed to be a minority. The appeal of wealthy companies and products from outside Ghana limits the home-grown innovation and as a result continues to put Ghana at service to the rest of the world.

The NGO community is one sector that hires a good number of engineers. In talking to several NGOs about this issue, however, there are some very important issues that should be considered. First of all, engineers and engineering services are expensive. A second, and even more important barrier, according to the director of one NGO I spoke with was the attitudes of the engineers. The engineers, in his opinion, had poor social/interactive skills despite the fact that their job requires a lot of social dealings. Engineers always seemed to think of
themselves as high class in the way they presented themselves. A situation has been created that causes the lay person to look up to the engineer, but the engineer has created a barrier in which he or she is inaccessible in many ways. In general, several of the NGOs I spoke to suggested that engineers can be very difficult to work with and that often skilled community members can do the job (although usually not as well.)

Technology in Ghana:
Technology in Ghana, like in everywhere else in the world, has a tremendous appeal – often too difficult to resist. Unfortunately, most of the modern technology in Ghana, however, is coming from across the border. Technology is seen as a status symbol and a solution to a wide variety of woes, including crime, energy shortages, and even poverty. In a recent study conducted at KNUST, it was shown that rural farmers much prefer foreign goods to local goods and foreign technology to local technology. The farther away it comes from the better it is.

Technology can be a status symbol that leads to social exclusion or debt. The cell phone is a perfect example. It is very rare to find a student at KNUST who does not own at least one cell phone – it is a social requirement. But for the very poor students, it is one more expense. Not having a cell phone leads to social exclusion. A professor in charge of issuing small scholarships for students in financial need says that he reads about the poverty of many of their students - many of the stories are heart-wrenching – but on the application form, everyone has a cell phone number at which they can be reached.

I asked many people throughout Kumasi and Ghana about the cell phone. Most people were very enthusiastic about the role of the cell phone. "Look what the mobile phone has done for Africa." "Mobile phones are reshaping Africa. It is good for business and good for the economy." And it is true that the cell phone has created a lot of opportunities. Several people I spoke to did point out the frustration of the constant ring tones and the high expenses for calls. Most disturbing however, is the increased amount of African money that is leaving the continent and going to foreign telecommunication companies.

Advanced technology is seen by many in Ghana as a critical component of development and progress of their country. It is difficult to argue with this position,
although its vagueness and ambiguity definitely need to be addressed. Most importantly, however, when considering technology, several things must be reflected on:

- where does the technology come from?
- is it necessary for us?
- who benefits the most from our use of this technology?
- technological changes always result in both good and bad sociological changes

There are too many Ghanaians who have the dream of catching up to the Western world who are embracing Western technology without really considering the repercussions.

**Engineering and Development:**

I sought out to learn more about how engineering was being used in Ghana to benefit the many people who share that country. In general I found very few people talking about the needs of the people - especially the poorest. The bulk of the engineering was for the benefit of the elite - the richest people in Accra, the government workers, and the foreign multinationals. The discourse discussed by the leaders of Ghana was about driving the economy and attracting business and, here's that word again, development. The general view about poverty is that it will be dealt with by making for a stronger economy. The belief is that a stronger economy will result in less poverty. So, essentially, engineering for development in Ghana usually means driving the economy.

I started to ask questions to try to connect engineering to social justice. I asked:

- Does the engineering profession have a role to play in performing duties related to human development and social equality?
- Should engineers be taught about their potential role in marginalized communities?

I got a variety of responses, but the majority of the people agreed that this would take a change in the way of thinking.

**Engineering education in Ghana:**

Education, like technology, is often cited as the solution to many of life's ails. Unfortunately, how someone is educated is a direct reflection of the opinions and values of the dominant class. A change in engineering education could be a great
means to get the engineering community thinking about how their trade can be used for the marginalized in their community. But changing the curriculum is difficult and currently there are not many professors who are talking about the most marginalized.

With Ghana being such a young country, most people can trace their family back to a village. And many Ghanaians speak of the egalitarian attitudes that were present in the village. If one villager has plenty when another has run out, they will share. But the university is full of people who have left poverty behind, and unfortunately the socio/political climate in Ghana right now doesn’t encourage these people to go back and work with the rural poor. Social convention does require those with money to send some back to family, and while this redistribution of money is useful for the poorer, it rarely helps anyone long term.

Much like in North America, the pressure on Ghanaian professors is large and they are often too busy chasing money and do not have much time for their students, let alone people from their community. In fact, the professors, often trained in Europe or North America will encourage their best students to go to the West. I spoke to one engineering professor about encouraging the students to look for helping the poorest citizens with their engineering skills and he said that the engineering students at KNUST know more about London or New York than they know about the marginalized in their own country.

It was refreshing, however, to meet several people who were excited about talking about engineering education and development. We talked about what the curriculum could look like and the merits of a development placement and we even talked about the spectrum between charity and social justice. There is currently very little focus on social issues or social sciences such as history and economics. Change in curriculum to teach more liberal arts, communication skills, and humility would be a great step forward. As more and more Ghanaians are heading to university, we must suggest that if university is for the masses, it must have a community component.

If engineering education is going to try to address development and the needs of community, there is going to have to be some discussion on exactly what that will look like. An engineering graduate student working in development says that there
are too many engineering development projects without engineers. A development student says that too many engineers are doing development projects without knowing anything about development planning. Engineers and planners need to work together.

**The socio/political situation in Ghana:**
At this point, I think it is worth while to write a little bit about the current culture in Ghana. There are many people who talked about the conditions in Ghana to be changing. There is a very real sense of national pride and optimism for the future, but there is also a frustration in the loss of many things that were once considered to be dear. In one of my conversation a Ghanaian student told me that Ghanaians are now very confused people and didn't know exactly what they were working for. (I told this student that Canadians were confused too.)

There is much talk about the improvements in Ghana - Ghana is getting better, leading the way, catching up to the West. There is a lot of talk about catching up. Most people are optimistic about the future of Ghana and the Ghanaian economy. The age of military coups seems to be a thing of the past. Ghanaians say that they were the first country to gain independence and will be the first country to lead Africa in the new African economy, the 'African Tigers'. The media is constantly talking about prosperity and long health for all citizens. But the majority of the people can not feel the improvements yet. One professor tells me that the economy is like air conditioning – if you have to ask if it is working, then it is probably broken. Many people – hostel porters, drivers, farmers, security guards, and even professors, told me about how tight money was and others talk about being stuck.

Out of one side of their mouth people say that globalization has been good for Ghana – more people eat meat now than before. But almost immediately, out of the other side of their mouth, the same people talk about how tough things are. There isn't enough money.

There is conflicting stories about caring for the poor too. There is evidence of a growing gap between the rich and the poor. While some people attain high levels of wealth, most people acknowledge their traditional role in caring for the poor. But this is not always seen. I’m told that it is hard to care for the poor now because of
all of the other demands - some are social demands, but others are perceived demands stemming from aggressive media and advertisers. In one interview, my interviewee said, "When we have money, we never think about the poor anymore. We used to, but now we think too much about catch up [to the West]."

A common conversation is about how things have changed. Many people talk about how things were better in the olden days. I guess this isn't much different that other cultures and in other times, but the changes are happening quickly in Ghana, even quicker than in North America. I'm told that there is a sharp increase in the levels of consumerism - I have no trouble believing this one based on my observations. Security and safety are growing concerns with an increase in the cases of armed robbery. (I wouldn't be surprised if this corresponds directly with the increase in the gap between the rich and the poor.) I'm told that the youth no longer show the elders the respect that they are supposed to and in turn, the elders can not relate or understand the youth. The elders say that the youth do not have the right morals and the youth say that the elders do not respect them. Perhaps this is the same story for all generations and for all times, but I'm told that the social conventions that have been followed for many generations are falling apart.

Life is hard for the rural poor and with so much focus on economic development, subsistence farmers are turning to cash cropping. Poor rains, hotter weather, and decreasing prices make conditions almost unbearable for the rural family. This results in mass urban migration. The mass migration into the city is also a cause for concern to many. Many slums and shanty towns are constantly being built by the immigrants and knocked down by the cities. The strength of the village or extended family is falling apart. There are many forces breaking up the extended family. Men are working away from their homes and their children are growing up without a father figure. Western Union stations are everywhere. Their ads show a very posh home and children playing with a caption that says, "Father is sending a lot more home than just money." Like many generations, the people realize the problems of their time, but it is not clear on how to proceed, and it seems like the changes are happening faster than ever before.

Despite the optimism that is present, there are a large number of Ghanaians who openly talk about their desire to leave. I was approached several times a week by Ghanaians who were looking for a formal invitation to aid in getting a visa to
Canada, in my case. Because of my skin colour I was often seen as someone who could help obtain a ticket out. It was a common and frustrating conversation. There is a belief that even cleaning the streets in Canada would result in a life 1000 times better than life in Ghana.

And Ghanaians seemed to love to debate. "That is the problem with Ghana," I'd often hear in response to a story about a corrupt immigration officer, an untimely power outage, or an abusive police officer. I probably heard the phrase daily. Ghana certainly is a confusing place where optimism and pessimism seem to coexist, coming out of the same mouth at the same time.

The streets in the city are crowded and there are children everywhere. As an outsider, I often wondered where everyone slept and what everyone ate. Often I was asked for food (chop) or money (dash), even from police officers. How does this place operate, I would often think. And yet life goes on and things seem to work someway.

**Development and the role of the foreigner:**
Life is challenging for many Ghanaians, be they rural or urban. Given the situation described above, the fact that foreign companies are going to continue to make money off Ghana's resources, and the fact that the standard of living is significantly lower than what we are used to in Canada, what is the proper response? Health, hygiene, water, energy, sanitation, and shelter are all things that are needed in Ghana. There is also a need for everyone to do something useful with their time. Can an outsider, be they engineer or non-engineer, be useful? How can help be best administered, if at all?

These are challenging questions, and I'm not going to pretend like I know the answer, but I do want to give some of my reactions based on my time in Ghana.

The issue of aid is one of great debate. Many people call for more or better aid. Some insist that aid must be untied, that is there is no expectations as a result of the aid. Others argue that aid is always tied – the lender is always in a position of power. A famous Kenyan economist even argues that many of the troubles with Sub-Saharan Africa are a result of the dependency that results because of aid and that Africa would be better off if they did not accept even 1 cent.
I am not personally going to speak as strongly as our Kenyan friend, but I can easily say that I've witnessed the dependency. When I was in Bimbilla, I saw a community that did not have enough water resources. The number of working bore holes was few and a fire in March of 2007 had destroyed the central water treatment plant. The water was coming from a stagnant pond and was not appropriate for drinking without treatment, mostly because of Guinea Worm. When I visited the community in June, the majority of the people were drinking, cooking, and bathing with very low quality water. The community was waiting for the next NGO to come by to fix the problem. This community lays in the region that used to be considered part of the mighty Ashante empire many centuries earlier. They were part of a kingdom that took care of themselves. They addressed their needs as they saw fit. I'm sure that there was still suffering and waterborne sicknesses, but their own community dealt with their own issues.

When I visited Bimbilla with a Ghana/USA development team, we met with a regional politician in Bimbilla. He said, "If you bring water, you bring life." His quote of a nice phrase commonly heard in Ghana, sounded nice, but his tone was completely absent of his responsibility. I almost felt that there was no life in Bimbilla until development agents came. Bimbilla was dependent on someone coming to drill a bore hole.

There are many International and Ghanaian NGOs in Ghana. There's a saying in Ghana that say, "If you want to make some money become a pastor or start an NGO." NGOs can help counteract the huge flow of money out of Africa - most of their money comes from outside. Every corner in Tamale had signs for an aid agency of some sort. I wandered into many NGOs in Kumasi - it seemed like they were everywhere, in little corners everywhere. And it seemed like most of the organizations were staffed by folks doing nothing. Or I should say waiting for something to happen. Waiting for a project, waiting for funding, waiting for anything.

The NGOs need to be accountable to their supporters and must show results. One man from the Jimmy Carter Center in Tamale explained that NGOs will never drill wells in the areas they are needed. There is too much risk. If after a couple of tries, there is no water, the drilling team will move to a community where the
drilling will be more guaranteed and the donors will be impressed with their results. This is why there are so many wells in the Volta region, but very few in the Northern region.

A successful development project must understand the culture. One woman told me a story of an NGO who built latrines in a community and they were never used. Years later it was discovered that the people believed that the feces from different families should never touch. Many stories like this were discussed as we drove through the Northern Region of Ghana. We were all humbled by the challenge we faced. One of the team pointed to the flat spread out community. "This area is so flat and spread out, would it be wrong to bring 1000 bicycles to the area?" We all sat in silence as we considered the question.

I think it could be very wrong. If the intention is to look good, for example, it is probably wrong. But it could also be OK - perhaps the answer is based on intent and process. Where did the money come from - through honest means? Will the bikes be used properly? How do you select who gets a bike? Do you know the people personally? Do they want bikes? Technology always influences society and these influences are always good and bad - we can't just pretend there won't be any negative consequences. What about maintenance? If your intentions are good, but your actions are not well thought out, you still risk great danger.

Rain water catchments are very promising technical solutions to water shortages. Could this be a good way for Canadian engineers to contribute? If Canadians do it, would the Ghanaians learn to do it too? Why don't the Ghanaians just do it if the need is there?

**The influence from outside:**
I've already discussed how so much in Ghana is coming from outside. Ghana imports chocolate from the UK, biscuits from Saudi Arabia, sugar covered peanuts from Malaysia, toilet paper from China, and if a Ghanaian wants some coffee they must drink Nescafe. China is building a new dam for Ghana to help with the power crisis. The Chinese give low interest loans and don't have as many strings attached. So the Chinese built a beautiful new soccer stadium in Tamale - the same community that could easy claim to be the NGO capital of the world. I'm told that the Chinese spend very little on the local economy - they stay in their own
hotels and eat their own food that comes from China. Even the Ghanaian cloth is made in China. The gold mines are owned by the South Africans. The Ghanaian beers are now bottled and sold by Guinness.

But it's not just stuff, it's also ideology. Everyone knows American movie and television stars. I watched at one home I visited as a young boy, barely able to walk, easily operated the DVD player, put in a Disney classic, grabbed the remote control, and headed for his seat. This home did not have running water, but the children could watch Beauty and the Beast. At least this boy wasn't watching a movie with guns, violence, and war - a sight I saw at another home with only slightly larger, unsupervised children. Everyone has a TV. When you enter a room, the host will always turn the TV on for you. I wonder if I was supposed to be more impressed. Cell phone ring tones, billboards, and t-shirts all contained messages from Western culture. From time to time I wanted to say, "You don't need a cell phone, you need clean water. You don't need TV, you need shoes."

But yet the outsider, the white people, continue to wow the locals. We brought our cameras and our laptops. We had nice clothes and worked in places where we had the solution. We represent a land of plenty. I helped my friend Mina from Holland unload a new motorbike at the hospital that she was working at. Over 50 Ghanaians watched. All of the many pictures of Jesus are white. A white Jesus is everywhere in Ghana. All of the mannequins are white. Even the black people in the ads are white.

Two grad students were preparing for their Masters thesis defenses at my hostel. The one student peppered the other with questions and the other coolly answered each one. Finally a question stumped the Master's candidate: he said, "Bring in the ex-pat." I interjected, but was told that dependency was better than frustration. I can tell many more stories like this. A fourth year engineering student tells me that it was much easier to get Helium for their project when the Czech engineering students were with them.

I tell people that many good solutions can come from the black people. I tell the young men that African women are as beautiful as white women. I tell people that life in Canada is not without its frustrations. I explain that cleaning the streets in
Canada will not make them rich. I tell them that Ghana is better than Canada in many ways, and they laugh at me.

Does development work perpetuate the attitude that solutions come from outside? Can we ever understand the complexities behind the apparent inferiority of the black person in Ghana? Knowing that we can not reverse the sins of slavery and colonialism, what can be done for Ghana to obtain true independence?

**Engineering education in Canada:**

All of the discussion above has been laid out to help bring me to a place where we can talk about how we educate our engineering students in Canada. The connection between poverty in Ghana and engineering education may not be immediately obvious, but often seeing another culture with fresh eyes can teach us to appreciate things about our own country and also show us how we can improve in other areas. Understanding Engineering Education in Ghana will help improve Engineering Education in Canada. The global nature of our world also teaches us about the way that we are interconnected. As I continue my research, I hope to further explore the connections between these two cultures that I have now been exposed to. One obvious thought that hasn't been discussed yet will be discussed in great detail later: an engineering placement for Canadian undergraduate or graduate students in a low income country like Ghana.

I like to start discussions about Engineering Education in Canada by asking lots of questions. ‘Why do we need more engineers?’ Should engineers be taught in the classroom or would apprenticeships be more fitting? What do we need our engineers to be doing? There is no doubt that someone who understand the physical, chemical, and even biological sciences and can apply this knowledge to make a useful device or process is important in any society, but what is the best way that students with engineering tendencies can be encouraged so that they are useful to their communities. How can engineering be used to improve relationships and to minimize suffering?

My feeling is that there are a lot of great things to be excited about when it comes to engineering education. It is an interesting, useful and challenging field. I do fear, however, that not only do today's engineering students have a difficult time connecting their knowledge to something useful for their community, there is a
growing apathy due to the fact that most engineering work today is performed for
the most wealthy people.

I see three immediate areas where engineering education in Canada could be
modified. First of all, engineering students need to be informed of the greater
social/political environment in which they will work. There has always been
discussion about how much the engineer should be exposed to the humanities and
unfortunately, in today’s climate, there is a horrifyingly minute amount of exposure.
There must be a balanced approach here – our engineers must be technically sound
– but engineers must have a deeper understanding of their social location. I will
not go into this further here, but it is essential for our engineering students to
understand how they are connected to others in the world. Informing our
engineering students about the shameful history of engineering and the oppression
of the powerful in the classroom is a must.

Secondly, our engineering students should be encouraged to work for the
marginalized. Engineering is constantly sold as a tool for the ruling class and there
is need to expose students to an alternate way. This could include working with the
poorest in Ghana or in Kingston. It could be argued that Engineering for Peace is
another option or that it is a necessity.

Thirdly, our engineering students could potentially spend some time on a
engineering placement. This would require crossing a cultural boundary and has a
great learning potential, but also a great potential to do damage. When looking at
the cost versus benefit, the direction the scales will be tipped will depend on the
character, attitude, and humility of the student and sending organization. I plan to
write a lot about this topic.

Where do we go from here:

So, where do we go from here? Well, I plan on finishing my thesis, but beyond that,
there are many things that can be done with Engineering Education at Queen’s and
elsewhere.

Reflecting on this experience has been very eye-opening, rich, and meaningful.
I’ve grown a great deal because of it and I am still a believer in Humanitarian
Engineering. I am simply reminded even further that it must be done with great care.

There are many stories that inspire. There are examples of engineers and engineering projects that have done some amazing things in marginalized groups. In my interviewing, I came across two stories that especially encouraged me. First of all, one African student talk about a time he was exposed to a teacher from America. He talked about how encouraging it was to see that the American was very human and fallible. That experience caused him to know that Africans can be equally capable of Americans.

Another story is from an engineer who saw a Western engineer who was working hard with the poor Ghanaian people. He came to realize that if a foreigner was not too proud to get dirty and help the people, then he should definitely not be too proud to work to help his own people.

With the right person with the right attitudes there is so much potential. With the wrong person, there is so much potential trouble.

This document was meant to be a brief summary of my experiences. I feel like there are many more things I could write, but I also feel like I have gone on too long. I should end it now and will eagerly await reactions and criticism.
Appendix G

Potential courses

This appendix lists some potential courses for a humanitarian engineering program. Tentative descriptions, outlines, and content have been written for several of these.

- Engineering Response to Disasters
- Water Issues and Human Development
- Appropriate Energy and Human Development
- Sustainable Housing and Infrastructure
- Human Mobility Devices and Human Development
- Information and Communication Technology for Development
- Introduction to Public Health Engineering
- Design Project in Humanitarian Engineering
- Design Project Implementation
- Engineering in Marginalized and Impoverished Communities
- Seminar Series and Community Work
- Field Investigations in Humanitarian Engineering
- Cross-Cultural Communication
Appendix H

Other names

This appendix lists some alternative names for the program in question.

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<th>Engineering and Humanity</th>
<th>Sustainability Engineering</th>
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<td>Global Engineering</td>
<td>Engineering and Development</td>
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<td>Engineering and Societal Sustainability</td>
<td>World Development Engineering</td>
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<td>Human Sustainability Engineering</td>
<td>Social Development Engineering</td>
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<td>Engineering for Humanitarian Development</td>
<td>World Engineering</td>
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<td>Engineering for Humanity</td>
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<td>Engineering and Human Development</td>
<td>Engineering in Society</td>
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<td>The Appropriate Technology Option</td>
<td>Social Impact Engineering</td>
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<td>Social Justice and Engineering</td>
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Table H.1: Alternative program names