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REPORT

Highland Lake Workshop
Conversations about Critical Action

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On December 6, 2014, Engineering, Social Justice, and Peace (ESJP) co-hosted a one-day workshop with Critical Stage and the University of Western Australia titled "Conversations about Critical Action." The workshop was hosted at the North American Cultural Lab in Highland Lake, New York. An interdisciplinary group of 14 participants from Australia, England, Canada, and the United States met, representing academics, artists, actors, directors, film-makers, activists, teachers and engineers whose common interest is in making a difference both individually and as a community.

Highland Lake

LakeWood House

Images from http://www.nacl.org

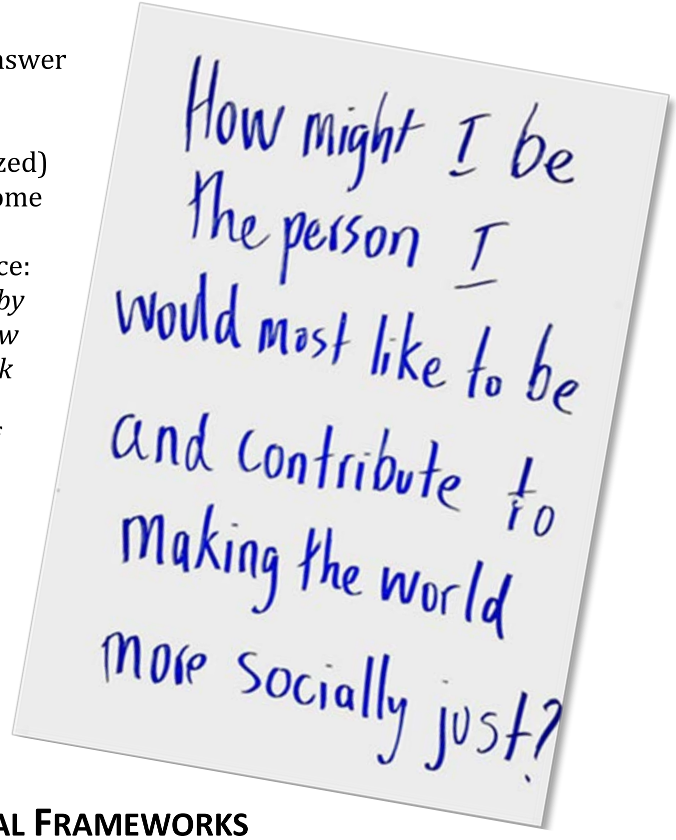
The conversation focused on critical reflections of past, present and future actions with the goal of enhancing social justice in discussing the workshop's main theme: *How might I be the person I would most like to be and contribute to making the world more socially just?*

Using an Open Space Technology format and Talking Circle processes with an interactive approach, the workshop participants developed self-organized sessions.

The participants identified the following topics to answer the workshop's main question:

1) How to unlearn/transcend our internal(ized) ideological frameworks in order to become capable of true change
2) The power of language and cultural difference: *What is your world? How is it shaped by geography, language, culture, geopolitics? How does that shape our struggles and work together?*
3) The role of Poets and Poetry in the work of social justice and in the world
4) How to stay true to ourselves in professional lives that often do not share our values
5) Visioning a "new new school" based in social justice

Participants closed with a reflection on what they noticed and made declarations and offers for the work ahead.



1. Unlearning/Transcending Ideological Frameworks

Many problems in the world are caused by ideologies with inadequate or biased value systems and ethical principles. As we grow up embedded in the existing value systems developed and perpetuated by the forces of privilege and injustice, we inevitably internalize their core premises. How and to what extent can we free ourselves and our worldview to become effective agents of change? Merely creating new ideologies and superior/humanist ethical structures is not enough if we remain co-opted and unable to unlearn these foundational biases. Or is it necessary to unlearn? For an ethical system agreed upon inside a room, amongst the like-minded participants, to meet and inspire wider community or to enact in the world, we need a robust shift at a foundational level (an example of the opposite process is described in Great Transformation by Karl Polanyi).

One participant suggested that we don't need to unlearn ideological frameworks, if this is even possible. Rather we can strive to transcend it. An analogy in math is that we first define objects (e.g. vectors) in certain coordinate systems, but later we transcend it to define these objects from any coordinate system. As we strive to reach new viewpoints we do that by becoming capable of seeing the world, communities, and people from multiple angles. Another analogy: we can define a colour in terms of primary colours and hue, but it is not how the brain processes them. It is capable of dynamically interacting in "nature coordinates."

Through these and other analogies participants reached a consensus that we don't need to unlearn the internalized patterns, but rather to transcend them through an interplay of empathy, learning through listening and through deeper identification with other complementary points of view. Ideally, one should reach the point where she or he sees the issues of social justice with clarity, not by replacing one set of lenses with another, but by becoming capable of transcending any original starting point. In a way, the nature of connections and interaction between the workshop participants illustrated by example how people coming from different backgrounds can share a commonly minted viewpoint on the interplay of engineering and social justice. On the other hand, the participants also recognised that the group makeup lacked broader racial diversity and that they predominantly are associated with academic life. The desire and challenge to expand along both of these axes was voiced during the wrap-up session.

2. Poetry and the Role of Poets in the World

The group talked about the ways in which poetry can help us recognize ourselves in others' experiences, and help us rediscover parts of ourselves lost to process of social conformity and injustice. It can remind us of who we are meant to be, who we want to be, and who we can be. Poetry is life-affirming and provides inspiration for our work.

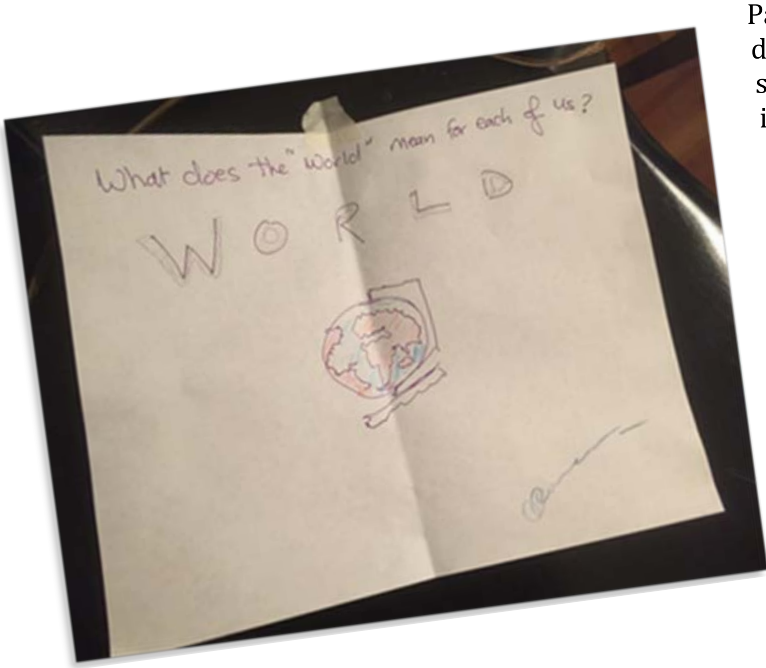
We can find our inner child. Children respond to poetry, and write poetry without adult inhibitions. While many of us have had the experience of spirited and colorful childhoods, we have also seen some of this fade away or be pushed out of us through schooling, or parents, or other forces.

As an adult, Mary Ann Evans, more popularly known as George Eliot, considered the plight of women locked into their adult bonds. The novel *Mill on the Floss*, which she wrote in 1860, relates the story of the protagonist Maggie at different stages of her life. We discussed the literary portrayal of the child locked inside the adult, particularly due to the gendered nature of freedom of spirit of the day and how this portrayal allowed us to remember our own childhood spirits—those force fields which know no bounds.

Poets bare their souls to the world. It is likely that Shelley and other romantic poets would be told today that they "feel too much" as some of us who care about social justice and peace are told. But in poetry we gain courage in the present moment, and we are sustained by ideas immortalized on the page, which travel through time.

3. The Power of Language and Cultural Difference

What is your world? How is it shaped by geography, language, culture, geopolitics? How does that shape our struggles and work together?



Participants discussed the effect of awareness of different languages as an enabler to understanding social justice. The discussion extended from the intended meaning of words in different languages and that languages could be a barrier in certain situations. The discussion about "my world" focused on how each one of us can have her or his own world and how we are all affected with what has been already learned. A participant gave the example of the world map we grew up with in school and how this world map can be seen differently through different views/lenses. One participant shared the Ann Sexton poem Housewife, the first line of which is "some women marry houses," revealing an astute critique of a single word and its implications of how women's roles are defined and maintained.

Another participant followed up with this topic and how she has experienced it in co-teaching a course in social justice with another instructor. “We were two very different personalities but with very similar sociocultural backgrounds. We were able to develop the concept of having the same frame but looking through different lenses; this helped us to teach students how to develop their own viewpoint based on this concept of frame and lenses.” The concept of *injustice* was also discussed and how an enhanced experience of injustice has led some people to be proponent of open source movement. Examples of injustice in different worlds were represented in a way that there is need to experience injustice or to have example of injustice explained in order to understand *justice*.

4. How to Stay True to Ourselves in Professional Lives that Often Do Not Share Our Values

How do we build supportive community that can sustain us in our work?

How do we make time for what really matters? One participant shared how a friend recently asked her to reflect on why she says “yes” to different projects in her life. Some are undertaken out of obligation, some out of guilt, and others out of passion. We talked about how we can increase the number of projects and the amount of time spent on our passions and less time on our obligations, and still less time on things we do out of guilt. Is it possible to see guilt as the flip side of passion? To what extent can we mold our obligations to incorporate our passions? Many of us have chosen to stay in our particular professions (most in academia), but at what cost?

Another participant shared advice they received to “work a little, rest a little, last longer.” In other words we need to take time out to avoid burnout. How do we schedule in our “ease time” and take it as seriously as other obligations and demands? One person shared how she struggled to maintain a rigid discipline of meditation in an eastern tradition but found that brushing the dog was itself meditative and created the space for her to work meditation and mindfulness practice into her everyday life.

What can we do to draw others to us? We talked about our strong sense of loneliness, how even when we reach out to allies in other fields, we sometimes feel alienated by a lack of common language or experience. Asking for help from colleagues can be powerful in building relationships with allies. It can help us name questions and find new language that helps us see our work in a new way. It can be energizing to find community in this kind of emergent action. In engineering education, with its history of military structure and links to our present economic systems, it can be transformative in itself to go about doing things this way.

At the same time the extra work we do to fit in can sometimes be exhausting. Sometimes our allies can betray us, and this can hurt more than the expected volleys from known enemies. We talked about finding the balance between protecting our hearts and letting ourselves be heartbroken. Sometimes we need to focus on tangible, achievable actions that are local and small scale, where we see a difference, no matter how small. Other times we can act with the sure knowledge that:

> “It is from numberless, diverse acts of courage and belief that human history is shaped. Each time a [person] takes a stand for an ideal, or acts to improve the lots of others, or strikes out against injustice, [that person] sends forth a tiny ripple of hope. And crossing each other from a million different centers of energy and daring, those ripples build a current that can sweep down the mightiest walls of oppression and resistance” (Robert Kennedy, University of Capetown, 1966)

We talked about where we find a sense of community—the people to whom we do not need to explain ourselves. One of us finds this on a women's hockey team. And many of us felt it in the space of the Highland Lake retreat. We agreed as a group to commit to create a Google Hangout group that creates regular (monthly) space for "ease time" and reflection, and accountability for our collective quest to stay true to ourselves. As one participant noted, our very souls are at stake.

One participant spoke to the power of art and design to create space for different ways of being, thinking, and doing. This led to a discussion about how we make our offices a refuge and a place that invites community. Many of us surround ourselves at home and at work with living things, especially plants and animals, which help us be and become more of who we are or strive to be. Art, photography, poetry, meaningful quotes, student work, all contribute to creating a space that reminds us of who we want to be. We are circulating a book by Ursula Franklin, who is a role model for many of us. We talked about some items that have failed to invite but have instead alienated others, and discussed the risks and rewards of seeking to shape some of the shared spaces on our campus. While it can be meaningful to realize shared space belongs to us as well, and we can have a profound influence on students and coworkers, at the same time, it can be painful to negotiate shared space when others do not share our values.

5. The New New School

The question was posed as to whether it was possible to create an alternative school which both transformed society towards a more socially just one, and acknowledged the emotional and emancipatory learning needed for such an education. We agreed to focus on engineering as a profession as this would draw best from our own expertise. We discussed the potential forms of pedagogy, the styles of teaching and mentoring, the location, the framing and the purpose. Many ideas emerged and as a group we agreed to take this existing project forward for our own ESJP community but also with the intent of modelling for other professions. We committed to research existing alternative schools with similar aims, and to explore the necessary next steps to begin our New New School.

Final Thoughts

Participants were invited to reflect on issues discussed during the day. There was a great deal of gratitude expressed for the workshop facilitator, for the venue, for those who planned and those who participated, and for the time and space for reflection. One participant observed a pessimism regarding the ethical limitations of institutions (academic in particular, but also societal, governmental) in responding to critical social justice issues, and observed that this is countered by natural instincts for robust ethical structures that inform "new" educational spaces and actions. There is a ready synergy existing between people from very different cultural localities regarding these challenges. There was a recognition that pessimism and cynicism can impede our ability to act and build community. We began to brainstorm some steps for practical action in the months ahead, and participants make declarations and offers in this regard.

For example, two participants agreed to convene an online hangout time for anyone who would like to check in about their progress in staying true to ourselves in professional lives that often do not share our values, and in building supportive community that can sustain us in our work. Others committed to extend the work of the ESJP community in creative ways, including developing a structure for online course delivery of ESJP themed courses, offering workshops to further our work together, contributing to the journal *IJESJP*, and developing inroads with engineering practitioners. Others committed to help develop the new new school. Others committed to change their teaching practices in ways that reflect what they learned at the workshop, and to write about their course innovations in engineering, social justice, and peace.

Looking back at the workshop, an additional benefit to the participants has become clear: we learned a new, effective technique of creating the question space, discussion space and follow-up space for all participants. We also experienced the power of follow-up commitments, one of these being this review. While we didn't spell it out as a specific task during the wrap-up workshop session, we formed the plan immediately following the workshop as we were preparing to depart from Highland Lake. Several of us felt that this was a natural emergence, in tune with the spirit of Open Space Technology. We hope by sharing the experience of the workshop in the journal that others can join in reflection and action on these themes.

Acknowledgment

The authors wish to acknowledge and thank all workshop participants for their contributions.

ARTICLE

Are There Ecological Problems That Technology Cannot Solve? Water Scarcity and Dams, Climate Change and Biofuels

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This paper illustrates through a comparative case study how contemporary engineers working on a technological response to climate change—biofuel production—continue to be guided by traditional ethical and historical principles of efficiency and growth in spite of the uniqueness of climate change as a problem unbounded globally in space and time. The comparative study reveals that in the past environmental issues like water scarcity were viewed as deficiencies of nature. In contrast, the development of biofuels as an engineering response to climate change shows that environmental and ecological issues today are viewed as deficiencies of technologies. Yet, just like large dams on rivers had (and continue to have) negative socioecological outcomes, political economy and political ecology research shows that current biofuel development has socially unjust and ecologically degrading outcomes. Many engineers continue to separate the "technical" from the "political" aspects of engineering work, resulting in lost opportunities to reshape the technological development paradigm. While every technology has some negative impacts, engineers, as socioecological experimentalists, must account for these outcomes in their work to mitigate them. Encouragingly, the engineers interviewed for this paper (along with the authors of this paper, who are all engineers) believe that problems like climate change are too narrowly defined. The engineers interviewed claimed that the problem-solving capabilities of engineers would lead to more favorable outcomes if problems were more broadly defined—by engineers and others—to incorporate concerns of social justice and ecological holism, thereby creating legitimacy for engineers in proposing alternative, radical, and paradigm-changing solutions to problems like climate change.

KEYWORDS: biofuels, climate change, dams, problem definition, technological solution, efficiency, carbon, political economy, aviation, socioecological experimentalist, science and technology studies

INTRODUCTION

Broadly, the prevailing self-image of engineers is that they are "problem solvers," and the image of engineering work is that it is about "solving problems."[1] Take, as illustrations, these reflections from practicing engineers (we describe later the source and circumstances of these quotes):

> [Engineers] are trained to be problem solvers. If you are able to describe, through interactions with other people, and frame the problem properly, generally, engineers can come up with a way to solve it.
>
> *A senior research engineer, NASA Langley Research Center*

[1] See Sheppard, Colby, Macatangay, and Sullivan (2006).

> [Engineers] are very good at problem solving. Once you define a problem, they can look and see what the causes are that are creating it, and figure out ways to approach those causes to remedy [the problem]. Generally, engineers are focused on more straightforward solutions and don't get distracted with some of the social, humanistic sensitivities that are associated with the problem. They are more direct for the [technical] solution.
>
> *An environmental consultant and co-winner of a Nobel Peace Prize*

But neither is the problem solving work of engineers solely technical, nor do engineers practice engineering in isolation—the discipline of engineering is *socially constructed* and has social and ecological impacts outside of the purely technical. Engaging in the "people-serving profession" (Vesilind & Gunn, 1998), engineers work within bureaucratic contexts, be they government, corporate, or academic. The problems engineers deal with have been framed in ways that reflect particular political motives and social and economic goals, as has been shown by significant research in science and technology studies.[2] The division of reality into "fact" and "value"[3] is perpetuated in engineering education and training, with engineers trained only to deal with the former, and either actively distancing the latter or reshaping it into the former.[4] For example, lifecycle analysis, which accounts for the material and energy resources used throughout the "life" of a product or process, does not account for the ecological, social, and cultural values and impacts of the resources, products, or processes. Furthermore, engineers are positioned within organizations and in the overall social and political order to bolster the industrial, capitalist economy.[5]

Engineers are not only problem solvers, they are also intentionally or inadvertently *socioecological experimentalists*; the problem solving work engineers do—whether it is inventing material technologies such as computer chips that require mined minerals and metals, building vast roadway infrastructures, or taking the tops off mountains for coal—is done often with limited understandings of the socioecological impacts of engineering work. While it is practically impossible to account for all outcomes and effects of a technology, to the engineers interviewed for this manuscript —as reflected in the second quote above and as will be discussed below—trying to understand these effects and impacts is currently beyond the scope of the engineering profession and hence bear little effect on the technical design process. Technologies—and by proxy the work

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[2] See, for example, Winner (1977). In chapter 4, Winner describes the power of scientific and technical elites and the relationship over larger masses of people that vie to make democratic claims. In chapter 6, Winner argues that in many cases, particular technologies that have *already* been developed are then applied to solve "problems" framed in ways that lend those technologies power. In this chapter, Winner also describes how and why large technical systems come to be controlled by the state. See also Mumford (1963). In this book, Mumford describes how self-imposed limitations on Western Europe allowed the creation of "the machine" and subsequently projected it as an artifact outside of "will." See also Hecht (2009) and Noble (1977, pp. xix, 34).

[3] We take the definition of *fact* to be something that stems from supposedly "objective" evaluations of the world. The scientific process is, for example, a generator of facts. We take *value* to be defined as something that guides how facts are acquired, or how facts are used. The political process, the give and take among groups with competing interests, is generally believed to be guided by fact. Different groups use different facts for their own advantage, and make claims with those facts consistent with their beliefs. See, for example, MacKenzie (1990).

[4] For examples see Noble (1977) and Porter (1995).

[5] Conversely, non-governmental organizations do not actively recruit new engineering graduates. Much can be said of this, but it is beyond the scope of this paper to detail why this is the case.

of engineers—thus shape our individual, social, and cultural behavior in ways not only expected but also unintended.

We live in a time when information about ecological degradation—climate change, biodiversity loss, air and water pollution—caused by industrialism abounds, a time when connections between technologies and the politics that lead to ecological degradation have been well established. Yet, in this paper, we ask the following questions: Has recent knowledge of ecological degradation and social injustice changed the way engineers consider socioecological problems? And how do engineers consider the capacity of technology to address such challenges?

The goal of this comparative case study is to examine whether and how past engineering thinking and decision-making is employed by engineers in the face of even larger and more complex socioecological problems. We consider engineering responses to two ecological "problems" displaced in time—the damming of rivers to address natural water scarcity in the American West in the early 20th century, and the current development of biofuels by the aviation industry in response to climate change, i.e. two "cases"—large scale responses promoted by powerful actors like governments and corporations. Specifically, we first briefly explore the historical context of the damming of rivers, the engineering ethic behind large dams, and their consequent negative socioecological outcomes. We then compare and contrast engineering approaches to "solve" climate change through aviation biofuel development in light of our understanding of the interactions between technological development, social justice, and ecological impacts. Interviews with engineers involved in aviation biofuel development conducted in October 2011 at the Third Sustainable Alternative Fuels in Aviation Workshop at the headquarters of the International Civil Aviation Organisation (ICAO), provide insights into how some contemporary engineers frame the problem of climate change and thus responses to climate change. Details on survey methods can be found in the Appendix at the end of this paper.

DAM THE RIVERS—"CONSERVATION" THROUGH USE

A century ago, the scarcity of water in the frontiers of the American West was perceived as an "environmental" problem, which was solved by large scale damming of the rivers—growth and development, guised under an ethic of conservation and efficiency, were imagined and created (Worster, 1985, p. 10).[6] Rivers were considered beneficial "when they yielded to humanity's needs, whether as mechanisms of transportation or as sites for nascent towns" (Ellison, 1999, p. 41). To achieve these aims, the federal government established the United States Reclamation Service (USRS) with the Reclamation Act in 1902, thus embarking on a program of irrigation development that relied on a favorite technology of conservationists—storage reservoirs. USRS engineers, especially Director Frederick Newell, promoted the idea of capturing spring floods in headwater reservoirs and putting the previously "wasted" water to constructive use (Ellison, 1999, p. 110).[7]

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[6] Take these quotes that capture the ethic guiding the human domination of waterways: "The conquest of nature, which began with progressive control of the soil and its products, and passed to the minerals, is now extending to the waters on, above and beneath the surface. The conquest will not be complete until these waters are brought under complete control." W. J. McGee, cited from *Water as a Resource* (1909) in Worster (1985, p. 127); and "One day, every last drop of water which drains into the whole valley of the Nile . . . shall be equally and amicably divided among the river people, and the Nile itself . . . shall perish gloriously and never reach the sea." Winston Churchill (1908) from McCully (2001, p. 18).

[7] Furthermore, in the early 20th century, people used "reclamation" to mean the process of turning desert or, much less frequently, swamp land into productive farmland, even though much of this land had never been farmland previously; there was nothing to be literally "reclaimed." The use of the term, however, points out

Dams were built to control the depth of rivers, to help navigation, to provide irrigation water to the arid West, to control flooding, and to generate electricity (Billington & Jackson, 2006, p. 17). Within fifty years of the late nineteenth century, the Imperial Valley of southern California was transformed by one of the most advanced hydraulic systems in the world, which continues to be elaborately modified to this day. The scarcity of water and the unchecked rivers in the American West were framed as a deficiency of nature, an "environmental" problem, which could be corrected through a single large-scale technology—dams—and today, on some rivers such as the Colorado, very little water makes it to the ocean.

These dams had overt economic and political purposes as well. In the early 1900s, citizens wanted the government to end the monopolies of the private electric power providers. Supporters of the USRS stipulated that the USRS could only provide water to farms of one-hundred and sixty acres or less—the established size for homesteads under American law—to ensure that government irrigation would support small family farms. Supporters hoped that "yeoman farmers" would improve the moral fabric of the nation. Irrigated farms would provide opportunities for the unemployed, immigrants, and other urban troublemakers, and convert them into valuable citizens for American democracy (Billington & Jackson, 2006, p. 8).

These political sentiments grew out of Progressive ethical traditions of efficiency, improved social bonds, and anti-monopolism (Ellison, 1999, p. 87); this was the Progressive "conservation" era of American politics. When Gifford Pinchot, the Chief of the U.S. Forest Service used the term "conservation" in 1907, it was already a mainstream American ethic. Progressive conservationists, who included federal engineers and scientists, made every effort to promote the ethic under the guise of national growth and strength (Ellison, 1999, p. 103). Time and again Pinchot pointed out that conservation did not mean protecting or preserving nature.[8] Rather, it was overtly anthropocentric; conservation stood for the control of nature and *efficient use* of natural resources to serve the material interests of humankind with an eye to long-term needs.

The political interests of the government and federal engineers guided the design of multipurpose dams. The ability of engineers to reduce the complexity of water storage and use into a differential equation allowed a technological "solution" to the problem of large-scale, multipurpose damming (Casler, 1926; Horton, 1918). These engineering designs promised the possibility of having full control over river water—not a drop would be "wasted." According to Hays (1999), conservation leaders were very active in professional circles, maintaining that their objective and rational thinking was superior to the give-and-take of politics:

> [l]oyalty to these professional ideals, [and] not close association with the grass-roots public, set the tone of the Theodore Roosevelt conservation movement. The idea of efficiency…molded the policies they proposed, their administrative techniques, and their relations with Congress and the public. . . . They emphasized expansion, not retrenchment; possibilities, not limitations. True, they expressed some fear that diminishing resources would create critical shortages in the future. But they…bitterly opposed those who sought to withdraw resources from commercial development. They displayed that deep sense of hope which pervaded all those at the turn of the century for whom science and technology were revealing visions of an abundant future. (Hays, 1999, p. 2)

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that Americans thought of a humid pastoral landscape as the norm and their technological interventions as an environmental return to normalcy (Ellison, 1999, p. 16).

[8] Thus, the conservation preached by politicians and administrative officials during the Progressive Era was much different qualitatively than the environmentalism emergent in the 1960s.

THE HARSH REALITIES OF DAMS

Engineers, who identified with the "conservation" ethic founded on efficiency and growth, were integral in *correcting the perceived deficiencies of nature through large-scale dams.* The scarcity of water and the courses of rivers in the American West were recast as environmental problems, creating a convincing rationale for creating large technological infrastructures that gave the federal government experience with hydraulic engineering, and allowed the breaking of monopolies, the provision of electricity, the navigability of rivers, the irrigation of desert and arid lands, and, in essence, the knowledge and tools to bolster the paradigm of efficiency and growth.

However, the technical expertise proved to be myopic and narrow, as engineers had limited understanding of the socioecological impacts of damming. Damming created an illusion of an abundance of water in arid areas and has led to every major waterway in the American West being dammed, with dam building peaking in the 1970s. The visually stunning nature of large dams has also inspired a correspondingly strong anti-dam activist movement (Goldsmith & Hildyard, 1984). The highly localized and immediate effects of dams—the displacement of people and the immediate destruction of ecosystems—provide a strong locus for rallying. Yet, large dam building is continuing at a rapid rate in the industrializing world, even after the emergence of clear evidence showing the ill effects of large dams.[9] Little of the food grown through the dam-irrigation schemes goes to those who need the food most. Millions of people are continually uprooted and forcefully resettled from their traditional lands to make way for dam reservoirs with the added risks loss of wildlife and estuaries, the loss of silt and fertility downstream of dams (Barrington, Dobbs, & Loden, 2012; Goldsmith & Hildyard, 1984; McCully, 2001). According to McCully (2001) and Goldsmith and Hildyard (1984), further negative effects of dams include decreased water quality, reservoir-induced earthquakes, increased water-borne diseases, and salinization of fertile agricultural lands. McCully (2001) shows also that the reservoirs created by dams release significant quantities of greenhouse gases. Indeed, anti-dam environmentalists have argued that water impoundments and clear cuts have also infringed on the rights of nature itself.[10]

BIOFUELS, AVIATION, AND CLIMATE CHANGE

Whereas water scarcity was identified as the environmental problem in the 1900s in the Old West, climate change is arguably the most important *global* environmental and ecological problem we face today. Greenhouse gas-emitting engines used in aviation are increasingly contributing to climate change as global air traffic continually increases.[11] ICAO corporations such as Boeing and

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[9] Goldsmith and Hildyard (1984) provide recommendations for alternatives to large dams, many of which encourage learning from past traditional irrigation techniques—the *qanats* of Iran, the use of *tanks* in the dry zone of Sri Lanka, alternate-year fallowing as practiced in Mesopotamia—and more fundamentally, learning to live with nature. McCully (2001) recommends changes in land management practices, flood management and rain harvesting, and basic plumbing infrastructure maintenance to reduce the need for large-scale damming.

[10] See, for example, "The San Francisco Declaration of the International Rivers Network" in McCully (2001, pp. 313–314).

[11] Aviation is responsible for 2–3% of total anthropogenic carbon dioxide emissions (Kahn Ribeiro et al., 2007). Aircraft also emit other greenhouse gases—such as water vapor, ozone, and methane, along with unburned hydrocarbons and particulate matter that have radiative forcing impacts on the Earth's climate—directly into the upper troposphere and lower stratosphere (Penner et al. 1999). In light of the growing impact of aviation emissions on the climate, the International Civil Aviation Organisation was delegated responsibility to address greenhouse gas emissions from international aviation by the 1997 Kyoto Protocol.

Airbus, aviation industry trade groups such as Airlines for America and the Air Transport Action Group, government regulation agencies such as the Federal Aviation Administration, and government-industry consortia such as the Commercial Aviation Alternative Fuels Initiative, have agreed that several measures will need to be taken to reduce carbon dioxide emissions over the next fifty years—operational measures, technical improvements to aircraft, economic measures, and use of biofuels.[12] While operational measures are changing (in air traffic control, for example); economic measures such as the European Union's Emissions Trading Scheme are being implemented by some governments (and vigorously fought by industry and other governments[13]); and technical improvements to aircraft are continually being made, the growth in overall air traffic has completely outpaced efficiency gains.[14] The aviation industry thus views biofuels as an essential technology that will eventually eliminate the industry's contribution to climate change. Intended to be "drop-in" fuels that would require little to no engine modification, biofuels would fit within the existing aviation infrastructure. To date, there have been several successful test and commercial flights using biofuels produced from non-food plants such as *jatropha curcas* and camelina.[15]

The perceived role of biofuels within the aviation industry is captured in Figure 1, which depicts the optimism that biofuels will eventually lead to a 50% decline in carbon dioxide emissions compared to 2005 levels. Biofuels, as many engineers, government and corporate officials, and technocrats repeated at the ICAO workshop, must be produced *efficiently*, so as to allow "carbon-neutral growth"[16] of the aviation industry for the foreseeable future,[17] which many claimed as essential to the economic growth of countries and improving people's quality of life. An aviation fuels specialist for the Federal Aviation Administration summarized the industry's vision of and confidence in biofuel development to enable this growth, also invoking efficiency as a guidance principle in technological development, by saying that:

> I am confident that [through] engineering resources . . . we will come up with solutions to make [biofuels] work, and make [them] efficient enough such that you can make a synthetic jet fuel for basically the same price as a petroleum derived jet fuel. I am extremely confident that we will be able to solve those problems.

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[12] See the Air Transport Action Group's web page about environmental efficiency in the aviation industry, (http://aviationbenefits.org/environmental-efficiency).

[13] For examples see Aviation Environment Federation et al. (2012) and Sundaram, Krukowska, and Lin (2012).

[14] Models developed by the Intergovernmental Panel on Climate Change (IPCC) show that by 2050, the greenhouse gas emissions from global aviation will grow to between 1.6 and 10 times the emissions in 1992, and that the emissions increase in their reference scenario is threefold compared to 1992, equivalent to 3% of the projected total anthropogenic CO2 emissions relative to the mid-range IPCC emissions scenario. Global passenger air travel has been growing steadily and quickly in recent decades, and is projected to grow by about 5% until 2015, whereas total aviation fuel use is projected to increase by 3% per year until 2015, the difference being due largely to improved aircraft efficiency, cited in Metz, Davidson, Bosch, Dave, and Meyer (2007). Therefore, it is widely accepted that the overall emissions of greenhouse gases will *increase* for the foreseeable future, and aviation's share of overall greenhouse gas emissions from transportation *will also increase*.

[15] For examples see "Finnair's scheduled commercial biofuel flight marks a step towards more sustainable flying, says airline" (2011); "Lufthansa's biofuel trial takes to the air with first commercial flight" (2011); and Reals (2011).

[16] See, for example, International Air Transport Association (2013).

[17] For the purposes of this paper, we take the notion of "efficiency," a common engineering design goal, and "growth"—the growth of profits, the growth of corporations, and the growth of industry—at face value. For detailed explanations of "efficiency" and "growth," see Daly (1977) and Princen (2005).

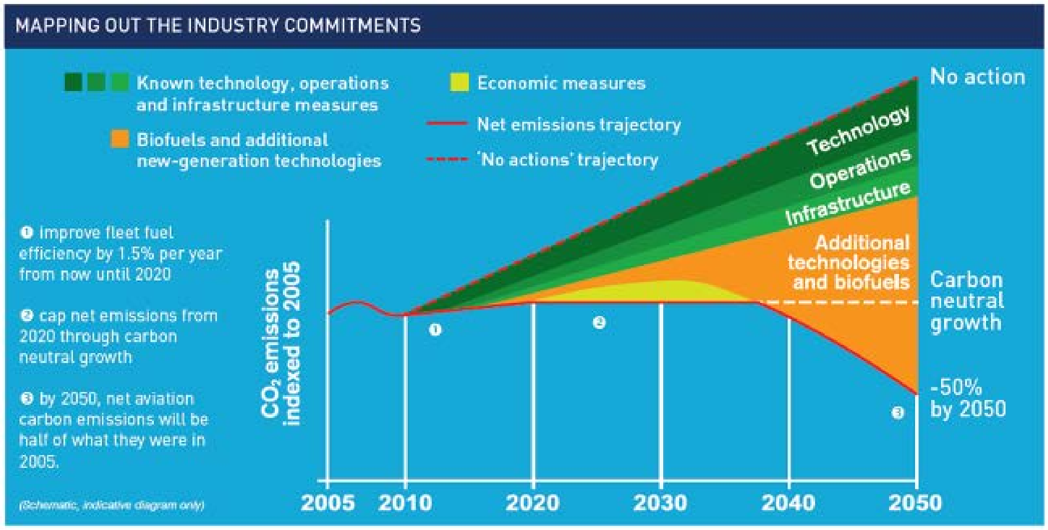

Figure 1: Of all proposed carbon dioxide emission reduction measures for the aviation industry, biofuels represent by far the largest potential source of cuts, thereby allowing "carbon-neutral growth" of the industry through close to the year 2040. Image courtesy of Air Transportation Action Group, (http://aviationbenefits.org/environmental-efficiency/aviation-and-climate-change/our-climate-plan/).

The unprecedented global problem manifested in climate change has not changed the paradigm of efficiency and growth through technological development, evident in the damming of rivers a century ago. Yet as we later explore through biofuel development in response to climate change, what engineers consider an "environmental" or "ecological" problem has in fact changed markedly since the early 20th century. Before we get there though, we briefly explore the socioecological and economic outcomes of biofuel development, and then show how our engineering profession continues to silo itself from the political dimensions of climate change, while bolstering the technopolitical regimes that have caused climate change (Hecht, 2009).[18]

The Harsh Realities of Biofuels

Biofuels are envisioned by governments and industry as a technological response to the interrelated problems of an "energy crisis," climate change, and dependence on the Middle East for oil, presenting a win-win-win scenario to the Global North and to the current economic system of growth (Borras, McMichael, & Scoones, 2010). It is in the Global South, however, where much of the biofuel feedstock is being grown. For example, major plantations of *jatropha curcas*, a biofuel feedstock of particular interest in aviation, exist primarily in Asia, Africa, and Central and South America, and approximately 15 million hectares are projected to be under cultivation by 2015 (Friends of the Earth International, 2010; Global Exchange for Social Investment, 2008). Governments and industrial agribusiness have touted that biofuel production will reduce poverty, enhance rural development, create employment opportunities, and create energy security (German,

[18] Hecht describes technopolitical regimes in chapters 1 and 2 as the interweaving of the technical and political aspects of engineering and nation building, the influences of which stretched beyond public discourse to influence all levels of technical development, "from the interactions between nuclear leaders and government officials to the artifacts and practices of reactor design" (2009, p. 56).

Schoneveld, & Pacheco, 2011). However, the optimism surrounding biofuels has not led to positive ecological, economic, or social outcomes.

Ecologically, biofuels have been tremendously negative so far, resulting in soil loss and water depletion (Borras et al., 2010). Palm oil biofuel plantations have played a huge role in the destruction of 80% of the Indonesian rainforests, which covered 77% of Indonesia in the mid-1960s (Gouverneur, 2009). The "carbon debt" associated with biofuel plantations can make biofuels a more significant source of carbon dioxide emissions than conventional fossil fuels (Fargione, Hill, Tilman, Polasky, & Hawthorne, 2008).

Economically, *jatropha curcus*, like so many other "miracle crops," has turned out to be neither profitable nor pro-poor and instead has benefitted middle-income to rich farmers who had access to capital. Further, poor farmers who have planted *jatropha curcas* have become dependent on investors. For example, in Tamil Nadu, diverse plantations that provided small and marginal farmers with food for self-consumption, fodder, firewood, and cash, were replaced with monocrop *jatropha curcas* plantations. Plantations required higher than expected irrigation inputs but yielded one-tenth of the forecasted crop. The widely held idea that non-food biofuel feed stocks such as *jatropha curcas* can be well cultivated where irrigation networks do not exist appears misleading (Ariza-Montobbio, Lele, Kallis, & Martinez-Alier, 2010). Deforestation to create sites for biofuel plantations has also made it difficult to access forest products, thereby decreasing self-sufficient supply of foods and resources (German et al., 2011). Local realities in industrializing countries show that "idle" or "under-utilized" land being bought by foreign investors are lands that in fact are neither idle nor unused, but rather provide important means of livelihood, particularly for women (Borras et al., 2010).

Biofuel development in the Global South has also had little to no focus on local social justice concerns, such as land rights, water rights, and employment. Compared to family farming, only one-tenth the numbers of jobs has been created by biofuel crop farming (Borras et al., 2010). Moreover, the majority of jobs on biofuel plantations in Indonesia and Malaysia have gone to migrants from outside the affected communities because the skill base and work ethic of local residents have been considered inadequate by managers (German et al., 2011). The distribution of benefits to the broader community have been undermined further by poor employment conditions for unskilled laborers and restricted access to economic benefits to employees (German et al., 2011). Dauvergne and Neville summarize how current industrial-scale biofuel development bolsters the paradigm that has created socioeconomic injustice and climate change:

> [P]roduction and consumption patterns of biofuels will benefit . . . [those] groups already integrated into commercial production systems . . . with even well-intentioned efforts to mitigate climate change and support development through biofuels likely to accelerate deforestation and further marginalize vulnerable people and ecosystems. (2010, p. 655)

Regardless of these negative impacts, the aviation industry is relying heavily on biofuels to mitigate the industry's greenhouse gas emissions while simultaneously enabling and ensuring the continued growth of the aviation industry. Engineers are involved in all aspects of biofuels—from production, storage and distribution to end-use. Engineers are also involved in setting research agendas and regulatory frameworks to enable biofuel development.

Biofuels and the Existential Pleasures of Engineering

Historically, especially in the Enlightenment period, technological development and the human shaping and manipulation of nature was understood to form the basis of a stable society. Social stability rested upon the ability to move away from an imperfect past and to overcome external limits forced upon humans by nature (Davison, 2001, pp. 67–72).[19] Dam building to combat the scarcity of water in the American West in the late 1800s and early 1900s is a quintessential example of this ethic. In today's world, philosopher and the author of *Technology and the Contested Meanings of Sustainability* Aidan Davison writes, "[t]echnological society names a particular political and moral condition in which the greatest common good is understood as the greatest possible productivity of technosystems" (p. 93). Biofuels are a technology thus being developed not only in response to climate change, but also in response to a perceived scarcity of fossil fuels to stabilize current modes of trade and economic interaction.

The engineer's analytical framework tends not to include intangibles like politics, emotions, and other ethical concerns.[20] Reductionism,[21] empiricism, positivism,[22] and dualism[23] form the cornerstones of modern engineering and technological development. Reflecting on the definition of what success is to an engineer, an engineer responsible for fuel purchasing in the treasury department at Delta Airlines said that:

> . . . building [a material technology] and having it work is a success [to an engineer]. That might be a different perspective than for the person who wants to use it, for good or for bad. . . . Whether this thing is a computer, or whether it is something used for chemical warfare, it's a success.

According to the engineers interviewed, the current metrics for success to engineers are purely technical, and metrics and tools to assess socioecological and political implications of engineering work do not fall under the purview of current engineering practice; these implications are evaluated by politicians, lawyers, economists, sociologists, and others. The *seamless web* of the political and technical thus continues to be recast into the *isolated spheres* of the political and the technical through the division of labor, and through the conceptualization of the technical as "fact" and the political and the generally non-technical as "value" (MacKenzie, 1990, pp. 413–414). Take, for example, this quote from a leading engineer for Energy and Environment at the Federal Aviation Administration (FAA):

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[19] See in particular p. 69: "In the world Descartes and Bacon saw, external limitations are overcome, and thereby progress attained, to the extent that rational knowledge about natural machinery takes over from the inefficient meandering of evolution. A lack of rational development in existing social practices, a lack of material advance, i.e. a lack of progress, appeared as backwardness, idleness, moral decay. Yet, notions of progress and stability do not stand over and against each other so much as they inform and shape each other. The Enlightenment idea of stability was derived instrumentally from the antecedent metaphysical conviction that the purpose of social life was to develop the raw stuff of existence into a rational form, a Paradise on Earth."

[20] See, for example, Vesilind and Gunn (1998, pp. 30–32).

[21] We understand reductionism as the division and discretization of complexity into well-defined parameters that can therefore be adjusted. An example of reductionism is how federal engineers converted the storage reservoir problem into a differential equation with terms that could be manipulated. Reductionism thus sets up cause-and-effect relationships, and is also referred to as "atomism"—see Hauser-Kastenberg, Kastenberg, and Norris (2003).

[22] Positivism, which is the application of the empiricist tradition of Francis Bacon and Isaac Newton, allows the engineer to stand as a supposedly neutral observer to the forces of nature that dictate empirical outcomes (Vesilind and Gunn, 1998, pp. 30–32).

[23] Dualism is related to positivism—it is the separation of humans from the environment, the distinction, particularly in Western philosophical traditions of mind and matter.

> [L]ast week, I was having a conversation with somebody about the [carbon dioxide] standard for [aviation], and [an] individual asked me, "Knowing what you know of the industry, do you think we can get them to cut a deal?" Cut a deal? We haven't even figured out how to measure [how changes in the aviation infrastructure will reduce carbon dioxide emissions] yet. . . . *We don't have any data*. . . . *I think that individual is reacting to [their] political realities*. (emphases added)

When considering what this engineer self-identified as a "moral issue," the engineer wanted "data" on the technology metric, i.e. the performance of the technology for reducing carbon dioxide emissions. As discussed next, several interviewed participants articulated that engineering solutions to climate change are currently limited to the technical. This is because of how the problem of climate change is defined.

ENVIRONMENTAL PROBLEMS: NO LONGER A DEFICIENCY OF NATURE

Climate change represents a vastly different kind of environmental and ecological problem than the scarcity of water in the American West. Even though the sources and effects of climate change are at local scales (just like the effects of dams), climate change is unbounded in space and time, has emergent, non-linear properties, and is likely to only show its full effects over the coming century and beyond (Beck, 1992).[24] Addressing climate change demands a new spirit of sociotechnical interaction (Jonas, 1984).

While the scarcity of water in the American West was considered a deficiency of nature, climate change is attributed—by engineers (and as discussed later, by governments and businesses)—to a deficiency of our technologies: "I think the climate change situation right now is an . . . unintended result of our technological progress," reflects the aviation fuels specialist from the FAA. Given that "solutions" to climate change commonly proposed by governments and industry are "non-greenhouse-gas-emitting" (at least over their lifecycle) technologies, it is clear to the authors that the specific technological deficiency causing climate change is that current technologies rely on combustion and thus emit greenhouse gases. Biofuels serve as the technological response to this perceived technological deficiency, as the chief executive officer of a biotechnology company claims: "The aviation industry would like to be zero carbon. So there is an environmental issue. Biofuels can [be zero carbon] if you use the right biofuels. . . . [Technologically] is the only way you are going to solve [climate change], I think." These quotes reflect the perception that the only problem with aviation is the industry's dependence on fossil fuels and the greenhouse gas emissions from their use, and that technology can adequately address this problem. According to engineers, then, is there an ecological problem that technology *cannot* solve? An Environment Officer for ICAO claimed that:

> [e]very technological achievement reflects the fact that we have learned something new . . . to the point where you can create something that leverages that understanding. We're getting to the point where we understand the environment more. So, that gives me confidence that with that improved understanding, we can then come up with [technological] tools to address . . . [ecological] challenges.

The CEO of the genetic engineering company argued further that:

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[24] For detailed descriptions of the nature of climate change, see also Nixon (2011, pp. 2–3, 266) and Princen, (2012).

> The reality is that technology has always solved social and environmental problems, like the Haber Bosch process, which they invented [to] make fertilizers. Before that process, the world was extremely concerned about how much fertilizer there was. And [people said],"Oh we're going to run out of food," and "We're never going to be able to meet all of these growing needs . . ." and [technology] solved that problem. . . . So, I think everything that is good comes from technology . . . and some of the bad things, too. But I don't think we should focus on that. Over and over, mankind has been able to innovate its way out of problems.

Placing these reflections in the context of the conference the interviews were conducted during—a gathering dedicated to "sustainable alternative fuels in aviation" replete with presentations from engineers who likely have progressive attitudes towards sustainability—and within the context of the broader discourse around how technological advance is necessary to address sustainability challenges, the above reflections provide illustrations that to many engineers, environmental and ecological problems are results of technological deficiencies that can be solved with *new* technologies, industrial in scale and founded on efficiency and growth. This ethos of technological development allows engineers to focus on purely technical work.

Climate change is, however, a problem that has at its root a socioeconomic and political order that has been shaped by combustion technologies for transportation and electricity generation that require fossil fuels; nation states and corporations have encouraged and subsidized greenhouse gas emissions (Mitchell, 2011). Responses to climate change derive from and rely on this very order, a conclusion was articulated by a scientist working for an international non-governmental organization (NGO) promoting clean(er) transportation:

> Why are we doing biofuels? . . . [I]gnoring for a moment [whether or not these statements are true], [biofuels] have a lifecycle analysis that says we [can achieve] a level of carbon savings. [But] *[n]o one has to do anything* (emphasis added). We're not going to charge anyone [or] spend any public money. All of the funding will be taken from the consumer at the pump, at a level that is too late to be noticed. We can chalk it up on our renewable energy targets [and] on our climate change targets. And we have *more* energy rather than less (emphasis in original). . . . We have a "*more* energy solution [that looks] great" (emphasis added). So, we love biofuels policy. . . . You ask, "What do we want to do?" Well, the last thing we want to do is change anything that we do. . . . [B]iofuels are a great way . . . of really not changing anything and "achieving change" . . . if you believe you are achieving change.

The technological fix (Weinberg, 1966) of biofuels is one that offers "engineering as an alternative to conservation or restraint" (Fleming, 2010, p. 8), particularly to the aviation industry. But technological fixes—instead of placing more faith in or trying to enact policy and behavioral changes—have come to connote "simplistic or stopgap remedies to solve complex problems, partial solutions that may generate more problems than they solve" (Fleming, 2010, p. 8). Note that planned reductions in air traffic are not considered by the aviation industry as a means to reduce emissions in Figure 1, re-enforcing the tenet that boundless growth will be enabled by engineering "solutions," the same tenet of boundless growth that endorsed the widespread damming of rivers in the old American West.

What Is the Problem?

Engineering has been thought of as the most liberating of professions; regardless of monetary and social concerns, engineers are freed to perform the technical tasks for which they were trained and which they find most pleasurable (Florman, 1994), and thereby to "solve problems." The participants interviewed recognize that they often do not define or frame problems (like climate change), but are instead handed problems to solve—"[y]ou are kind of taught not to ask questions, [but rather to] just . . . design [technology]," said the Delta engineer. A senior environmental consultant for the aviation industry commented similarly that, "[s]o often, engineers are employed by industry or somebody who is looking to solve a very near-term problem that can be narrowly defined, and so that's all engineers are asked to do and that's what they do." The engineer's work is fragmented, with individuals making small contributions to much larger projects, whether it is designing turbines for a pump in a dam or a transistor for an integrated circuit. Further, the engineer's positions in large corporate and government bureaucracies are "designed to diffuse and delimit areas of personal accountability within hierarchies of authority," and there is pressure on engineers to move on to new projects before operating projects have been observed for long enough to observe and analyze performance and broader impacts (Martin & Schinzinger, 1996, pp. 94–95). Therefore, says the Delta Engineer, ". . . engineers, like accountants, get stuck in a little bit of a [closed world]. . . . Why isn't an engineer a whistleblower when he's creating some horrible, horrible chemical weapons? Because that's not their role." Engineers are thus distanced from the moral accountability of their work, and have consequently "continued to serve capital, wittingly or not, their habits of thinking about problems and formulating solutions constituting for the most part but a highly refined form of capitalist reason" (Noble, 1977, p. 323). The most recent science and engineering labor statistics published by the National Science Board (2014) imply clearly that technical work continues to bolster for-profit capitalist businesses and corporations.

The tendency to understand problems, analyze information, and propose actions through the lens of technological development is created through engineering education, the paradigm of which was established during the early days of the professionalization of the engineering profession (Noble, 1977; Seely, 2005), and according to Seely (2005), substantive progress in revolutionizing engineering education to include non-technical content remains stagnant. This technological development lens decontextualizes the technical and scientific tools from the world the tools were developed for by institutionalizing specific epistemologies of what constitutes "factual" knowledge (Murphy, 2006, pp. 81–110),[25] enabling engineers to dismiss non-technical forms of knowledge and ethical concerns as "soft" or not quantifiable and therefore outside the realm of an engineer's consideration. The NGO scientist commented that:

> . . . policy questions [run] into problems when you ask scientists and engineers because you get an awful lot of cognitive bias. . . . In general, if you ask a bunch of scientists a question, they are going to try and come up with a scientific solution. If you ask a bunch of engineers a question, they are going to want to build something. . . . [Y]ou already know what the answer is going to be before you ask them. [So], the question is, [since] you know what the answer is going to be, do you think these people are the best people to ask the question to?

Engineers form essential nodes in the network of actors involved in technological design. As the people who are handed problems to solve, engineers' world views thus propagate an ethos of efficiency and growth through techno-optimism. Framing an ecological problem as a technological deficiency allows engineers to combine their existential pleasure of creative problem-solving effort that is embodied in technological projects with the intention of "[contributing] to the well-being of his fellow man" (Martin & Schinzinger, 1996), thus reinforcing, perhaps unintentionally, a narrowly

[25] For example, in the case of sick-building syndrome, claims of the negative health effects of working in modern office buildings, with their plastics and ubiquitous chemicals, were countered with the epistemologies of industrial hygiene that required toxic exposures to chemicals to be both regular and specific, which rendered the effects of constant low-level exposures improvable and imperceptible. Therefore, dominant epistemologies and ontologies shape the framing of a problem for those that are trained in those dominants, rendering alternative and opposing framings powerless.

technical belief system, which in turn stabilizes a particular technopolitical order. Environmental and ecological problems consequently serve as the impetus for technological development, with the environment serving as the source of material inputs of technology, as well as the sink of outputs and fallouts of technology.[26]

Yet, interviews with several participants also revealed a more nuanced reshaping of the current engineering paradigm with the movement of social and ecological concerns to the forefront of engineering thinking, as shown next.

ENGINEERS REEVALUATING THE PROBLEM

We posed the question to our interview participants, "What are two or three things that engineers are good at, and two or three things engineers are not so good at, related to thinking about the environment?" and their responses indicated struggles with the limited design space allocated or assigned to scientists and engineers. The Delta engineer observed that:

> I think oftentimes the impacts on the environment [are] sometimes not known when the technology is being created. [For example], folks thought corn-based ethanol was the most brilliant invention ever. Then they realized, "Wow, we are running out of corn, and people aren't eating," or [since] corn was subsidized . . . farmers in the [United States] stopped growing wheat and they moved to corn . . . and the price of wheat [went] up. . . . We may not know what [technology] really does damage and what doesn't. . . . When it comes to the environment, I think that [understanding what a success is] becomes very, very difficult because there is no framework anymore.

Notions of sustainability, including climate change and water scarcity, require broader thinking than is currently employed in engineering work, as the quote above reflects; engineers are indeed socioecological experimentalists: engineers manipulate physical artefacts, and develop and construct technologies and infrastructures without a full picture of the broader impacts of their work; they are experimenting and hopefully apply learning from their experiments to their next exercises. The aviation environmental consultant elaborated on this point, noting how ecological damage could be seen as an unintended consequence of engineering work:

> Many times the problem is too narrowly defined. So you have a lot of unintended consequences that end up as [a negative] environmental or social impact. . . . [Engineers tend to look] for the immediate problem, and they don't draw the bounds of what they are studying broad[ly] enough. If they did, I think they would come up with better solutions.

This statement implies that engineers *do* have agency in defining what "the problem" is, and that their ability as problem solvers can allow them to propose more holistic solutions to problems. Further, engineers are increasingly considering the social and ecological effects of technologies, as reflected in the following comments of the CEO of the genetic engineering company: "[E]nvironmental and social implications have come to the forefront of scientists' and engineers' thinking. More people will now ask you about lifecycle analysis. Thirty years ago nobody would have asked, 'Do you have a lifecycle [analysis] for that?' " It is thus imperative that educators train

[26] Murphy (2006) describes how the framing of problems and accepted technoscientific norms dictate responses to those problems. Actions to address problems are taken only when understood by the powerful in the language they have created and under the norms they have promulgated. Murphy describes how sick building syndrome (SBS) emerged and materialized as an occupational illness in middle-aged working women, and how its existence was questioned and rendered imperceptible to industry-sponsored toxicology.

engineers to incorporate broader social and ecological concerns into engineering work. The authors of this manuscript argue that engineers of all kinds and at all levels must be involved in transforming the current technically-focused engineering paradigm into one with public legitimacy in advocating for more nuanced and thoughtful responses to social and ecological problems. As it stands, the NGO scientist remarked:

> How do we solve climate change? Engineers have a limited toolbox. . . . They don't deal in behavior[al] change. . . . People know that their job is to engineer and science-ize. [But] then if . . . an engineer comes back to you and says, "It's all fuckin' ridiculous. You should just all ride bicycles," people will say, "Why are you telling me this? You are . . . an engineer. What do you know about getting people to ride bicycles?" Not only do [people] know the answer [they] are looking for, but [they] are also sort of predetermined to reject an alternative type of answer, because [they] don't trust engineers' [non-technological responses].

In summary, argues the Delta engineer, the existential pleasure of separating the technical aspects of technological development from the political and generally intangible aspects is "probably what engineers are good at *and* what they are bad at. It's good because [an engineer] can get something done without bringing emotion into it, and it's bad because you don't step up and [ask], 'Is [developing this technology with this parameter space] really a good idea?' "

CONCLUDING THOUGHTS

When in the past engineers perceived the scarcity of water as a deficiency of nature, engineers now perceive problems such as climate change as deficiencies of technologies. In both cases, technological solutions were and are encouraged. Specifically, notions of efficiency and growth pervade the current engineering response to climate change just as they did a century ago when rivers of the American West were dammed. While the engineers interviewed believed that most if not all ecological problems could be solved using technology, the interviews also revealed that engineers could be better equipped to address large socioecological problems like climate change if the problems were defined more broadly than just technological problems. Solutions to climate change that consider social, political, economic, environmental, and ecological facets provide the best opportunity to redefine the current engineering paradigm and the technopolitical regime that has caused climate change.

In practice, however, biofuels development continues to separate the "technical" from the "political," resulting in a lost opportunity to reshape the technological development paradigm. Climate change is being used as an opportunity to develop new technologies without questioning the industrialism and capitalism that has created climate change. Framing a problem like climate change as a technological deficiency has unleashed a tsunami of capital investment, incited debates about government regulations and market distortions, and prompted concerns about intellectual property and competition, just as previous technological developments like dams or genetically modified foods have. "Carbon-neutral growth," for all its apparent balancing of the economic and the biophysical, remains a goal founded on *efficiency* and *growth*, both economic and physical. Unless accompanied by changes in socioeconomic behavior, technologies tend to perpetuate established socioeconomic outcomes (Pfaffenberger, 1990).[27]

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[27] In the case of irrigation schemes in Sri Lanka's dry zone, the change to land-based rights access to irrigation water during British rule turned the gravity-flow irrigation system into a socioeconomic differentiation mechanism that created capitalistic class hierarchies, when in fact the previous water-based rights access had allowed equitable access to irrigation water. It was not the technology that had changed, but rather the socioeconomic and political contexts within which it existed that caused drastically unequal outcomes.

Climate change represents a system destabilizing problem (Hughes, 1987), and the framing of climate change as a “carbon” problem is “possibly the greatest and most dangerous reductionism of all time: a 150 year history of complex geologic, political, economic, and military security issues all reduced to one element” (Princen, Manno, & Martin, 2013). To frame climate change as a carbon emissions problem is to invite what Princen et al. (2013) call “end-of-pipe” solutions where “the problem” is that which occurs at the point of combustion—carbon dioxide emissions—and it is the carbon dioxide that must be dealt with through advanced energy solutions. To go upstream—to refining, distribution, drilling, and exploration, let alone investment and, yes, technological development—is to necessarily frame the problem as a complex set of socioeconomic and political decisions influenced by nation states, corporations, and engineering firms. Yet another way to frame the problem, as the significant body of work in political ecology, political economy, and political sociology has shown (Ariza-Montobbio et al., 2010; Borras et al., 2010; Dauvergne & Neville, 2010; German et al., 2011) is as a matter of social justice, particularly when large-scale responses such as biofuels unfold on the local scale.

An important case study to guide future engineering education and technological development is to investigate the role of engineers as political actors working close to or at biofuel plantation sites. In particular, researchers should explore how the engineers integrate local social justice concerns into their work. Research that highlights innovative problem definitions and solutions that challenge traditional engineering paradigms can serve as critical foundations for changing engineering education and practice.

The reality is that every technology causes some negative impacts, at a minimum through consumption of finite resources. That does not mean that we should abandon technology, but rather that we—engineers—need to be better socioecological experimentalists by better accounting for the problems technologies cause so we can mitigate them. Indeed, the engineers interviewed for this paper believe that the problems they deal with are too narrowly defined. Instead, we must live and design within ecological bounds. The authors believe that the problem-solving capacities of engineers can be best used if they are given the more agency and expertise to frame problems technologically *and* socially and ecologically (Karwat, Eagle, Wooldridge, & Princen, 2014), thereby creating legitimacy for engineers in proposing alternative, radical, and paradigm-changing solutions to problems like climate change.

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APPENDIX: STUDY METHODOLOGY

Data for the dam case study involved researching literature on the history of dams, focusing specifically on the framing of the scarcity of water as an environmental problem, and the underlying ethic that guided the federal government and engineers in embarking on a mission that has left every major waterway in the West heavily dammed, with many unintended and ecologically harmful consequences.

To explore engineers' conceptions and technological responses to climate change, one of the authors conducted ten individual, one-half to three-quarter hour, semi-structured interviews with engineers and scientists involved in biofuel work in the aviation industry at the third Sustainable Alternative Fuels in Aviation Workshop at the headquarters of the International Civil Aviation Organization (ICAO, the United Nations body that oversees international aviation) in October, 2011. These interviews provided us with empirical examples of how contemporary engineers and scientists think of problems like climate change. We analyzed interview responses through historical comparison and by placing the interview responses within the context of the philosophy of technology and science and technology studies. The main questions of the interviews were (not all of these questions were asked to all participants given the trajectory of the interviews):

- What are the key features involved in your engineering and technological decisions?
- At what point do you personally consider the social/environmental/ecological impacts and outcomes of a technological solution?
- What gives you confidence in engineering and technology to solve social/environmental/ecological problems?
- What gives you confidence that biofuels will be able to combat aviation's impact on the environment and climate change?
- Is there an environmental/ecological problem that you think technology cannot solve?
- In your experiences as an engineer, how much do you think engineers are involved in framing what "the problem" actually is? Do you think engineers are actually involved in framing what the [climate change] debate is?
- What are two or three things that engineers are good at, and two or three things engineers are not so good at related to thinking about the environment?

ARTICLE

A New Vision for Mining Education—First Steps

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This paper narrates the experience of a Canadian university in reorienting its mining curriculum towards the goal of producing engineers who are sensitive to context. The authors acknowledge industry's historical association with environmental degradation and imperialism, but counter that mining is necessary to provide the materials of civil infrastructure, particularly that required to reduce greenhouse gas emissions. They also point to the potential for mining projects to rejuvenate communities, by providing the revenues that support self-determination, suggesting that more equitable distribution of impacts and benefits may be achieved through engineering design that is better informed and sensitive to community perspectives.

To promote such an approach to engineering design, the Robert M. Buchan Department of Mining at Queen's University has instituted a program of curriculum re-positioning that is informed by theories of situated and transformative learning. This paper traces the first steps in the development and execution of curriculum that supports the development of student awareness of context and culture and a new contextually-sensitive approach to professional practice.

KEYWORDS: Mining, engineering education, engineering ethics, environmental ethics, social responsibility, sustainability, curriculum

INTRODUCTION

Historically, the extractive sector has had a poor environmental record. In recent years, offshore incidents involving human-rights abuses at Canadian-owned mines (Leahy, 2006; Macdonald and Rowland, 2002; Mendleson, 2012; Payne, 2014; Popplewell, 2009; Sandborn, 2010) together with Aboriginal protests over development on traditional lands (Ball, 2011; Bigué and Hudon, 2008; Freeman, 2013; Halley, 2013) have brought into sharper focus the many social costs borne by affected communities. The potential for extractive projects to inflame social and cultural tensions is a major concern for advocacy organizations, policy makers and industry. As a result, the last thirty years have seen stricter legislation, increased scrutiny from civil society watchdogs, the proliferation of voluntary industry standards and the promotion of the Corporate Social Responsibility (CSR) function to corporate status, all of which have contributed to improved performance on many fronts, particularly environmental impact. However, competing cultural narratives of development, which are also highly contextual, continue to complicate the resolution of social tensions.

Notwithstanding the fact that mining projects can bring employment and economic opportunity to remote communities (Brereton & Forbes, 2004; Evans, 2013; Martin & Newell, 2008; World Bank and International Finance Corporation, 2002; Triscitti, 2012) even the best-planned have potential to cause environmental disruption and social destabilization. Environmental responsibility has already been woven into the academic treatment of mining engineering—in every university mining department, researchers work to develop cleaner production processes and more reliable impoundment technologies in the quest to minimize environmental damage[1]. Additionally, as a requirement of program accreditation, students of mining engineering in Canada are now taught that their professional responsibility includes ensuring that design and operational decisions minimize environmental impacts. In Canada, and increasingly in other jurisdictions, ever more rigorous regulatory regimes underscore this responsibility. And, while researchers in fields such as sociology, public health, geography, politics and development studies have documented the harmful social effects of mining on communities, it is only relatively recently that *mining* schools have begun to contemplate how they might teach their own students about the profound social and cultural impacts of the very industry that will employ them. Equipping graduates with skills that will enable them to critically evaluate particular social contexts and identify opportunities to develop engineering approaches responsive to community concerns has not been part of the traditional undergraduate curriculum (Baillie, Pawley, and Riley, 2012).

An approach that is being explored by the authors is to conceptualize community concerns and aspirations as functions of culture, which might be addressed through engineering practice. We contend that while culture alone does not fully explain a community's view of itself or its response to proposed development, including extractive projects, the acquisition of a comprehensive understanding of the political-economic-historical context of a particular community is also inadequate as a foundation for effective dialogue with affected communities. So-called "cultural" or "cultural sensitivity" training, which typically includes an introduction to this history, as well as to the overt practices and communicative preferences of a particular group, has since mid-twentieth century been routinely offered to engineering professionals and executives to enhance their performance in multi-cultural teams and their ability to conduct business globally (Pusch, 2004). Such training has focused on presenting the history and etiquette associated with specific cultures. Typically, the focus of these programs has been neither on the skills and attitudes of the learner, nor the function of self-awareness and empathy in facilitating meaningful—rather than either expedient or superficial—dialogue. In contrast, *intercultural competence* (Deardorff, 2006) approaches the facilitation of trust-building and authentic dialogue through development of a complement of skills and *learner attitudes.* The concept of intercultural competence has a loose and evolving definition, but nonetheless, has been shown to have practical value for predicting attitude change and adaptability to unfamiliar cultural contexts. Using the Bennett *Intercultural Development Inventory* (IDI) to track development of student attitudes and skill over time, we plan to evaluate the effectiveness of curriculum interventions in effecting a permanent change in the values of our own cultural community, the mining engineering department at Queen's University in Kingston, Ontario.

Currently, cultural differences in worldview enter the curriculum only through *cultural safety training* (National Aboriginal Health Organization, 2006), which is offered to final year students by staff from Four Directions, the university's Aboriginal cultural centre. The training introduces them

[1] Cleaner production fulfils many goals. From a business standpoint, more efficient technologies for processing contribute to lower production costs, increasing profits. At the same time, investment in improved energy efficiency has profound implications for the environment, particularly in isolated communities and in the North, where the only available energy source is diesel. Similarly, the quest for lowered water usage may be motivated by cost control, but nonetheless improves environmental performance. In jurisdictions where environmental regulations are more stringent, research into process and design innovation are similarly motivated by profit: minimizing costs of compliance with evolving standards illustrates the role of policy in creating conditions that balance support for business with driving innovation.

to Canada's colonial history and the pervasive intergenerational effects of trauma inflicted on Aboriginal peoples by systemic policies of assimilation. This background is certainly essential if students plan to work within Canada, but without directed intervention designed to promote the development of both *self-awareness* and a *sense of agency*, mining students are unlikely to embrace the task of re-conceptualizing the roles and responsibilities of either the mining industry or their profession. Our current research investigates how we might effectively integrate opportunities to develop self-awareness, the themes of social responsibility and agency into an already dense technical curriculum in order to equip students with the knowledge and skills needed to meaningfully bring social and cultural awareness into their practice.

We begin with the belief that mining engineers are well placed to become catalysts for the evolution of a more equitable relationship between communities and industry for two reasons. First, the professional responsibilities of mining engineers afford unique opportunities: over the progression of a project through the stages of the mine cycle their responsibility for the design of all aspects of the mine project provides opportunities to respond constructively to community concerns and aspirations *before* culturally damaging design decisions are taken. Second, during the construction, operation and decommissioning stages of the cycle, mining engineers are onsite, with unmatched opportunity to interact with and even become members of the community. To take advantage of these unique and substantial opportunities to build trust, engineers must be capable of recognizing them and appreciating the interplay of social trust and good engineering decision-making.

Our research thesis is that curriculum supporting the development of socio-cultural sensitivity and trust-building skills (orientations and skills in the affective domain) will prepare engineers to contribute to the creation of the respectful and resilient relationships needed to earn and maintain the *social license to operate,* a concept which is now widely accepted as an invaluable component of project success (Boutilier & Thomson, 2011). The social license conceptualizes the nature of a community/extractive company relationship in which the community is an informed and willing host with documented influence in decision-making and where benefits and risks of the project are managed collaboratively. From the perspective of business, the maintenance of the social license is an effective hedge against social risk because it can minimize the threat of community-level conflict that could result in revenue loss due to disruptions to operations or even project abandonment. Critics such as Kemp and Owen (2013) charge that the *social license to operate* reassures industry but fails to fulfill its promise to empower communities. Craig Ford, the former VP of Corporate Social Responsibility at Inmet Mining, concurs, arguing for replacement of the term *social license to operate* with *privilege to operate,* a term that implicitly challenges some of the assumptions inherent in a *license* (2014).

We contend that social risks are now so significant in mining that communication and cultural sensitivity should no longer be viewed as complementary skills for engineers in mining engineering, but rather, should be considered as core *engineering* skills within the discipline. In this paper we discuss initial steps taken by the mining department at Queen's to incorporate relationship-building skills into its curriculum, particularly at the undergraduate mining level.

Why Mining Education Needs a New Focus

The 2013 Annual Review of the International Council of Mining and Metals (ICMM) was titled *Strengthening Relationships with Communities*, reflecting the refocusing of priorities by the 21 major member companies, on community relationships as a key measure of environmental and social performance. ICMM President Anthony Hodge has said that the landscape for industry has changed dramatically even in his six years as head of the organization. Indeed, Hodge has stated that today's single most significant determinant of a project's success is neither ore grade nor financing, but *relationship with community* (March 6 2014, speaking to students at Queen's). The importance of forging strong relationships is echoed by Marketa Evans, Canada's former Councilor for the Extractive Sector, who has argued that trust-building is industry's *greatest challenge* (2013). Yet Kemp and Owen (2013) report that in spite of wide acceptance that community relations (CR) is core to business success, most mining companies still assume that CR is the sole responsibility of the community engagement staff and contracted consultancies.

As Ernst & Young Global confirm in their annual advice to the investment and corporate management communities (2013), social risk continues to threaten mining projects around the globe. Social risk may be defined as strategic risk that derives from stakeholder challenges to business practices, based on real or perceived impacts on human wellbeing (Befeki, Jenkins & Kytle, 2006). Interest in the management of social risk is due to its relation to profitability, yet the persistent failure of operators to engage effectively with the people who will be directly affected by mine projects illustrates industry's difficulty comprehending issues in the socially perceptive or culturally fluent manner that would lessen this risk. Although continuing conflict might appear to offer evidence of intransigence around community concerns, it is important to be fully cognizant of the gap between the reality of industry's present perspectives on its obligations to society (i.e., to create shareholder value and to a lesser extent contribute to the national economy) and the enlightened perspectives (i.e., to ensure that the communities that host resource extraction projects do not shoulder disproportional cost of impacts, and that they enjoy benefits *defined on their own terms*) that we aspire to for the future. We do not claim that the human and ethical dimensions of extractive projects influence the corporate agenda; however, the growing risk to profit posed by the status quo suggests that business cannot continue "as usual." Ironically perhaps, the threat to the bottom line becomes an advantageous starting position for re-conceptualizing the process and responsibilities of relationship (First Peoples Worldwide, 2013).

From this starting position, we are beginning to explore the potential that increased emphasis on socio-cultural skills within the mining curriculum might have for contributing to an incremental shift in the ways in which extractive operations are conceptualized by those in decision-making positions. While the enduring desire for precious metals and gemstones does suggest the need for serious soul-searching on a global scale, there is virtually no debate on the question of our need for industrial minerals. Even in the putative post-industrial West, where heavy industry has all but disappeared—having migrated to jurisdictions that offer cheap labour and loose environmental regulations—the products of the extractive sector are still required. Providing the major components of civil infrastructure (which many climate scientists and theorists argue must be enhanced and extended to more of the global population if global warming is to remain checked), mining remains an imperative. This is in spite of its record of negative environmental impacts and complicity in oppression, and the apparently intractable problem of inequitable distribution of impacts and benefits. Notwithstanding reservations we may have (which are shared by many within the industry) about some of the practices of resource extraction and asymmetric distribution of impacts and benefits, the pressing question is not whether mining development should/should not continue, but the immediate and far more complex question asked by Armstrong, Baillie and Cumming-Potvin: "How we can ensure that necessary minerals are obtained in a responsible way, i.e., observing the principles of environmental ethics and social justice?" (2014).

Some critics argue that corporate values are fundamentally incompatible with meaningful progress towards social justice and environmental stewardship. Whether or not this is true, we have chosen to set the argument aside in second and third year courses, in favour of a focus on impacts, specifically, the implications of various engineering approaches on environmental and social impacts.

Becoming a more reflective engineer is a prerequisite for the adoption of a more informed, open and critical position on any charged topic, including on the role of corporations within an equitable and functioning society. In second and third years, we concentrate on supporting students' enculturation into their profession—learning to "think like engineers." Past research, particularly that which analyzed the culture of the engineering study/workplace for young women and minorities, indicated a tendency for successful students to defend practices and attitudes that they would otherwise be expected to view unfavourably while others struggle to reconcile self with a professional identity that privileges "masculine" qualities (Adam, 1997; Chu, 2007; McIlwee & Robinson, 1992; Saavedra, Araújo, Taveira, & Vieira, 2014). Authors of these studies have suggested that during university and early in their careers, students are motivated to identify as members of a community of practice, and that any criticisms or reservations they may have about the group's cultural values are subordinated to the desire to fit in. By the fourth year (when they take the sustainability course), we surmise that students are beginning to become comfortable in their identity as mining engineers—most have, by this time, participated in the profession as summer students at mine sites—and are better positioned to participate in a more critical analysis of the industry. One of the goals of our curriculum changes is to nurture the development in our students of a sense that reflection is a necessary component of the engineering mindset, and that as engineers they have both agency and a responsibility to effect change. Students learn that the corporation is a social construction, which behaves as it is constituted to behave. Building upon their understanding of this fact, we can introduce and support the acquisition of the knowledge and skills that will enable students to move beyond critique towards action—responding to corporate agendas from a position of agency in the context of their profession.

The tension between social/environmental risk and potential for cultural renewal and community well-being that characterizes the global mining industry compels us to help our students contextualize the work of the mining engineer within corporations. Modern mine design and mining methods require huge investment and thus, the corporate structure and culture of the industry have been accepted, for the most part without question, within mining schools. We might have approached our educational objectives via a critique of corporate capitalism, but because industrial scale mining has potential to play a contributing role in environmental stewardship and social justice, we take our immediate task to be the realization of that potential. Within our technical courses, we see a place for introducing students to the roots of community mistrust. We explore the experiences of communities, especially those emerging from a colonial history, and introduce the concept of culture as a fundamental determinant of worldviews. Assignments that invite reflection upon their own epistemic assumptions support the development of an expanded conception of what it means to be an engineer.

We ground our approach in the situated learning theory of Lave and Wenger (1991), placing learning activities within a social context that allows students and practicing professionals to experience culturally determined attitudes towards mining *together*. Professors model sensitivity to the values and experiences of affected communities, while industry support for our initiatives serves to reinforce cultural sensitivity in practice as a *professional norm*.

Over the course of their studies at Queen's, students are challenged to discard the assumptions about engineering that they brought with them. Combining the principles of both transformative learning (Mezirow, 1991) and situated learning, curriculum changes that have been implemented and those in the planning stage seek to ensure that the next generation of mining engineers appreciates the human and environmental dimensions of their work and that they are equipped with the insight and tools needed to address the issues that arise as a consequence. We contend that a sustained effort in this aspect of their education will contribute to the intentional cultural shift that is known as *social innovation* (Westley, 2006)—the phenomenon whereby a series of small shifts in cultural values reaches a threshold or "tipping point," beyond which, cultural changes cascade to create new norms—here, norms respecting the epistemic values held by future generations of mining engineers and consequently, the approach taken to their practice. This, we believe, will contribute to building genuine—that is, *respectful, resilient, and lasting*—relationships with communities.

Mining Engineering at Queen's University

The Department is fortunate to have received a substantial endowment from alumnus Robert Buchan, the founder of Kinross, specifically to facilitate curriculum enrichment and ensure that the department will continue to have the resources to teach and provide experience with evolving best practice (in technical terms), but also that the curriculum will enable students to comprehend and address the social and environmental implications of their work.

In the sections that follow, we trace our first steps towards this curriculum. We present examples from MINE 422, *Mining and Sustainability*, MINE 201, the foundation course in mining, MINE 341, the introduction to surface mining, and the Graduate Certificate in Community Relations (GCCR), a new program designed to enhance the knowledge and skills of people working in community relations.

The First Step—A Course About Mining and Sustainability

In response to emerging industry standards and in anticipation of the coming Canadian Engineering Accreditation Board (CEAB) requirement that all Canadian engineering programs include training in sustainability, the mining department introduced a stand-alone sustainability course as an undergraduate elective in 2007. Since then, the department has embarked upon a gradual reorientation of the entire curriculum to ensure that a critical perspective on the environmentally and culturally complex context in which mining occurs is integrated throughout technical courses as a norm.

In its Minerals and Metals Policy, the Government of Canada offers guidance on conceptualizing the term "sustainable development" in the context of the extractive sector. Four principles are embodied within this conception:

- Finding, extracting, producing, adding value to, using, re-using, recycling, and when necessary, disposing of mineral and metal products in the most efficient, competitive, and environmentally responsible manner, using best practices;
- Respecting the needs and values of all resource users and considering those needs and values in government decision making;
- Maintaining or enhancing the quality of life and the environment for present and future generations; and
- Securing the involvement and participation of stakeholders, individuals, and communities in decision making. (Natural Resources Canada, Minerals and Metals Sector, 2000, p. 3)

In our re-orientation of the undergraduate mining curriculum, we have employed this distinct meaning of *sustainability,* in the context of resources that are inherently non-renewable, as our starting point.

Mining and Sustainability, was developed as a third year course by the aforementioned Anthony Hodge, a geological engineer whose extensive experience in the mining sector—including work with government, civil society organizations and industry—led him to the role of North American lead on the International Institute for Environment and Development's Mining, Mineral, and Sustainable Development (MMSD) project. The MMSD initiative sought to reconcile the practices of mineral extraction and processing with a broadening societal commitment to sustainable development (International Institute for Environment and Development, 2002). Hodge shared with students his perspective that mining has unique potential to bring benefit to society and that industry itself must take steps to ensure that environments are safeguarded and communities find themselves stronger and healthier as a consequence of mining. This vision was nascent in 2007, but Hodge's passion for the potential social contribution of mining was well received by third year students who enrolled in this course.

Hodge introduced students to such concepts as industrial ecology, full cost accounting, and the *Seven Questions on Sustainability* (Hodge, 2004)—presenting sustainability as an engineering problem where additional and competing constraints can only be balanced when all the stakeholders have meaningful input. Perhaps Hodge's personal story as much as his teaching ability contributed to the success of this course: in 2007, most mining students had not been meaningfully challenged to consider the harms caused by the industry or to imagine how things might be done differently, much less to consider their own responsibilities for effecting this change. Perhaps because Hodge so compellingly told stories that linked credible industry experience with his growing realization of the potential for doing better, perhaps because he challenged preconceptions with questions and good humour, or perhaps because students who chose this elective course were simply already open to a new perspective, the course was a great success, as indicated by formal evaluations and by numerous requests for a second course that would delve deeper into the issues and explore opportunities for contributing to improved outcomes for affected communities through mining. It must be noted that at this particular time, before environmental and social responsibility had secured their place in the corporate board room, many engineering students were deeply skeptical about sustainability, rejecting the messages of those who encouraged critical thinking about impacts (Johnson, 2009). A less accomplished person or more accusatory approach to critique might have been met with defensiveness by students eager to take on the identity of mining engineer. Hodge though, presented a visionary and empowering model of the responsible mining engineer who embraces a problem: a technically skilled professional who, acknowledging industry's historical association with hegemony and inherent risk, applies his knowledge of what is technically possible to the improvement of performance in the areas of environmental and social impacts. He portrayed the mining industry as a wonderful place to be because of its particular blend of human and technical challenges. Acknowledging past and indeed, some present irresponsible and unethical practices, Hodge impressed upon students the opportunities (as well as responsibilities) offered by their education—supporting the development of their ability to reflect—to constructively and critically analyze ways of practicing, impacts and possibilities for improvement—as well as a sense of agency to bring improvement into action.

By 2008, Hodge had taken up his position with the ICMM and was in the process of moving to London. The course timetable was compressed to accommodate his schedule. For two week-long blocks, students arrived at 8 AM daily for a 90 minute class—a very early start and very dense delivery format compared to what students are accustomed to in a standard twelve week term. The course was still an elective in 2008, but the class was consistently full of attentive students.

The instructors who have taught the course since have each brought a distinct focus to the integration of sustainability within the curriculum. From 2010 to 2012, the course was viewed through the lens of systems ecology, when it was taught by post-doctoral fellow, Samir Doshi. After completing doctoral work at the University of Vermont, Doshi had gained experience working with the coal-mining communities of Appalachia. He was interested in reclaiming abandoned mine sites and re-empowering disenfranchised communities through facilitation of intergenerational sharing of stewardship knowledge. In Doshi's iteration of the course, students learned about natural systems, the concept of "tipping points," and resiliency. Adding a graduate version of the sustainability course (MINE 722), which included seminars enabling a deeper exploration of diverse areas of interest, Doshi brought an interconnected, ecosystem framework to the discussion of mining's impacts. He led students in an exploration of multi-disciplinary approaches that may be required to adequately comprehend and address them. The living environment and human's role within and relationship to it formed the dominant theme in both courses.

Vic Pakalnis followed, bringing a focus on occupational health and safety to the sustainability professorship, extending expertise gained through years of regulatory experience in Government of Ontario's Ministry of Labour[2] to broader applications in communities where mining development occurs. Pakalnis was most interested in the social and economic components of sustainability, and the themes of economic opportunity, building infrastructure to improve standards of living, and community empowerment characterized his iterations of MINE 322. Pakalnis shared with students an interest in improving participation in industry, in decision-making capacities, by those most affected by mining's presence. He was particularly interested in encouraging Aboriginal[3] Canadians to consider engineering careers. Working with colleagues in the School of Policy Studies, Pakalnis was instrumental in organizing several national symposia (2008, 2010, and 2011) that focused on issues of concern to Aboriginal Canadians—whose communities in the north are co-located with much of Canada's mineral wealth—and potential roles the energy and resource sectors might play in facilitating greater participation in project development as well as in incubating a diversified economy within affected communities. The most recent, in 2011, gathered community leaders, scholars and policy makers to identify the barriers to higher education facing Aboriginal youth. A seminar within this conference brought together representatives of mining companies, educators, and community leaders to work on strategies for building capacity within Aboriginal communities by recruiting and supporting Aboriginal students in fields associated with mining (particularly those in the sciences and engineering).

Jeffrey Davidson joined the Department in 2011. Davidson, an anthropologist who later studied mining engineering and mineral economics, brought years of in-the-field experience in community relations, having been influential in the early development of more progressive engagement policies implemented by companies such as Placer Dome and Rio Tinto. In addition to assuming the professorship of the sustainability course, Davidson created the graduate course MINE 860 *Mining and Human Rights*, a vehicle for sharing his unique expertise in the problems of artisanal mining and international conventions respecting human rights. A notable achievement of this course was the enrolment of non-engineering students. Students from the departments of politics, environmental studies, global development studies and geology contributed varied and critical perspectives to the course, which explored the many ways that mining projects have negatively impacted communities. The methods and perspectives of these different disciplines gave graduate students in mining direct experience working towards a shared analysis of highly complex social issues, as they completed group tasks that simulated negotiations, corporate planning, and policy development related to the linkage of trade, foreign aid, and domestic and international operations

[2] In Canada, both labour and mining are regulated at the provincial level
[3] In Canada, the term "Aboriginal" is legally defined and refers to persons who identify as belonging to one of the following ethnic groups: First Nations, Inuit, and Métis

by Canadian firms. Role play has been a dominant teaching method in the course, and students enthusiastically "get into character" bringing an authenticity and pathos to the concerns that often lie at the heart of conflict. In subsequent iterations of the course, students have been drawn from Policy Studies and philosophy. The centrepiece of Davidson's tenure however, is the mandate to develop a graduate program in community relations expressly for the extractive sector. The *Graduate Certificate in Community Relations* (the GCCR program), is described in a later section.

The *Mining and Sustainability* course has reflected the interests of each successive instructor, whose areas of expertise were very different. Now that the national accreditation body has mandated an undergraduate sustainability course, it is clear that a consistent set of learning objectives must be identified and variations in content and perspective subordinated to their achievement. As the work of integrating principles of sustainable practice into the core technical courses progresses, the content and focus of the undergraduate sustainability course must continue to evolve.

Re-Envisioning the Entire Curriculum - MINE 201 Introduction to Mining

Undergraduate programs in Engineering and Applied Science at Queen's have a common first year. Within this year of general science and professional skills, students encounter some specific disciplines (geology, computer, chemistry and materials, math and physics/mechanics/electrical), but they are not introduced to mining directly. Thus, for the majority of students, their first experience with the multi-faceted domain of mining only comes in second year, *after* they have selected their discipline. This fact provides the department with a unique opportunity for shaping student understanding of the professional culture and values of the discipline. In the theory of *situated learning*, Lave and Wenger introduced the concept of the *community of practice,* a social grouping that develops in the context of skills acquisition and performance—learning to perform a complex task set that combines specialized knowledge, motor skills and decision making procedures and heuristics (1991). They contend that the novice—here, the second-year student of mining engineering—has a profound desire to become an accepted member of his or her chosen community of practice—to identify and be recognized as *mining engineer*—and that this desire makes novices to a profession or trade particularly impressionable, eager not only to absorb the knowledge and acquire the skills of the group, but also to adopt its *affective and cognitive style*. The second year courses in mining and mineral processing provide an opportunity to revise and enrich the curriculum in order to ensure that the moment a student identifies as a "Queen's Mining Engineer," she or he will also identify as a contextually aware and professionally engaged social actor.

Research has shown that students resist direct challenges to their perception of so-called professional culture and values when the challenge is perceived to originate outside of the group. Even at early stages of their professional training, students displayed a narrow range of responses—from resistance to resentment—to invitations to engage in constructive criticism of current engineering practices. Baillie and Johnson (2008) found that first year engineering students rejected encouragement to reflect upon the implications of their practice, and instead, concluded that particular teachers were promoting attitudes inconsistent with professional norms. From this it is very important to seize the opportunity to articulate professional norms immediately upon a student's entry into professional training. As noted, most students who enter the mining program at Queen's do not have previous experience of the extractive sector, so the introductory courses of second year have a formative influence on student perception of what *mining engineering* is all about and a normative influence on what comprises its professional values. In addition, the CEAB has required that *sustainability concepts* be covered within all accredited curricula since 2008;

offering a stand-alone course in sustainability was a first effort, which fulfilled this minimum requirement. However, the stand-alone model suggests that sustainability is an add-on, subordinate to “real” mining, and coming in fourth year, misses the window for imprinting mining engineering’s (re-envisioned) cultural values as students learn together. For these reasons, MINE 201, the introductory course in mining and mineral processing taught for the past three years by Dr. Josh Marshall, is the decisive course in terms of meeting learning objectives from the affective domain. If we want the next generation of mining engineers to value environmental stewardship and respect for communities, their education must equip them with the tools to operationalize these values, and their learning experience must encourage them to see critical reflection about human and cultural concerns as integral to engineering work.

From the first class each year, Marshall connects the human dimension of mine development into his discussion of the mining cycle. In recent years, the interplay of context and technical approaches to mine development have become inextricably linked through students’ experience on field trips that form the basis of a series of learning activities. In 2011, the class travelled 26 km north of Kingston to a small mine, which was at the time, in the permitting phase. The Canadian Wollastonite Company’s mine is situated within a farming community, 1 km south of Seeley’s Bay, a village of approximately 550 households.

This field trip offered students an opportunity to experience first-hand the environmental and social problems that surround mineral development. By reading local newspapers, and speaking directly with people in the community and with the mine’s owners and engineers, they learned about community concerns—noise, dust, increased heavy truck traffic—that can be mitigated through fairly straightforward means, as well as about concerns that are more difficult, or even impossible to fully resolve—anxiety and distrust. Students walked through the mine site (approximately 300 acres of privately owned land, upon which the owners live) and had the opportunity to learn about the process of environmental assessment and the types of impacts that even a small mine imposes on an ecosystem. The mine owner led the class through the site, describing how he had worked with the Queen’s Biology Department to obtain baseline environmental studies (determining the variety and population of flora and fauna on the property), risk assessments (the risks posed by mine development and operation to wildlife habitat) and best-practice approaches to habitat protection that can be taken in the design phase. Student interest was visible as mine owner shared the excitement he had felt when biologists showed him how mine planning could contribute to conservation of the black rat snake, an endangered population, by creating sites suitable for hibernacula in areas clear of mine activity. The owner pointed out the mitigation techniques that had been and were being employed to address community reservations—seeing the dense border of pine and fir trees planted fifteen years earlier to provide a visual and sound buffer to mine operations, students gained a sense of the long timelines associated with responsible development, as well as of the large number of areas of specialized knowledge that must be brought together to ensure the mine has minimal negative impact.

Assignments that built upon the mine visit required students to explore divergent opinions around the mine development (protection of the rural heritage and pristine water supply vs. generation of revenue for three levels of government and opportunities for well-paid employment in an area that has fairly high unemployment) and to consider how these tensions might affect a small close-knit community. While they were not permitted to directly contact members of the community on their own, students were given a package of materials similar to what would be included in a social impact assessment. Their assignments required them to research, evaluate and determine costs of various methods of addressing stated concerns. During their first term in mining engineering, it was expected that the approach would be quite high-level, and this was the case. Some students obviously spent additional research time, and offered quite detailed plans for mitigation along with thoughtful commentary on financial implications.

The course required students to learn about the permitting process and its complicated and multi-jurisdictional legal requirements. They learned that cautious planning and expert-designed mitigation of impacts may not satisfy all members of a community. They learned that community *perception* of risk and benefit plays a critical and inextricable role in the ability of a project to move forward. They learned firsthand that the pillars of sustainability are inextricably linked and that environmental concerns contribute to social issues and most importantly, that there are many problems in mining that cannot be solved by calculation.

MINE 201's 2012 field trip needed to accommodate a much larger incoming class (75 vs. 45 students plus teaching assistants), so the group travelled to Timmins, a northern Ontario town that owes its existence to the development of surrounding mines in the early twentieth century. For three days, different companies hosted this large incoming class. Unfortunately, logistics prevented the entire class from touring each host site, but roughly one third of the students were privileged to meet and talk with Anishnaabek elder Martin Millen at the Aboriginal Learning Centre at Goldcorp's Porcupine Gold Mine operations. Just as the trip to Canadian Wollastonite had opened students' eyes to the many non-technical considerations that are part of responsible mine-planning, the experience of learning about herbal sources of medicines, and the spiritual significance of water and animal life in the area of the mine to the local community made a strong impression upon students. Many had not considered the implications of site design for the nearby community and for most students this was their first encounter with Aboriginal teachings. The following summer, several students applied for summer positions at this mine specifically, because they wanted to learn more about the company's approach to working with the peoples from the nearby First Nations and how they might become better engineers by understanding culturally diverse perspectives on "responsible mining." During the summer of 2014, students from the same group sought and obtained summer internship positions in locations (Alberta, Peru) where there was an opportunity to observe and participate in projects that must obtain local consent. One student used the opportunity to talk to the local people and to collect their stories—these will inform his fourth year thesis.

Mine 341 – Introduction to Open Pit Mining

Ursula Thorley, who holds the Allied-Nevada Chair in Surface Mine Planning and Design, teaches MINE 341 (the open pit course), which introduces students in their second year of mining to the methods that create the most visible and arguably most lasting environmental impacts. Learning to manage the delicate balance of constraints and resources is the over-arching objective of the course. With several years of industry experience as a design engineer working in precious metal mines and in the bitumen mines in Alberta's Athabasca oil sands, Thorley has an informed appreciation of the many impacts and benefits of this massive industry. Before beginning doctoral work, Thorley was responsible for the design of waste impoundment facilities for Syncrude. Through this work, she developed a concern for the ability of the current regulatory framework to safeguard the environment over the long-term. An engineer, Thorley embraces the challenge of "solving a problem" but recognizing the limits of current technology. Her research explores the adequacy of sureties required for long-term impoundment of mine waste and whether policy makers need better models for incorporating costs of waste management and environmental monitoring into determination of mine profitability.

The particular social impacts associated with large scale mining are discussed in MINE 341 in the context of mine planning. Students learn the advantages and disadvantages of training and employing a local workforce, compared with operating with a fly-in/fly-out workforce. Using richly detailed case studies and data sets from existing projects, assignments and a major project ask students to experiment with different scenarios using simulation software.

In 2013, the MINE 341 class had the opportunity to participate in a four day field trip to Fort McMurray, the hub of the Canada's petroleum industry. A group of 20 students elected to join the trip which included tours to three production sites as well as to equipment maintenance facilities. The small size of the group was conducive to lively discussions about "life in Fort Mac" between students and the alumni who acted as guides. Many on this trip had travelled to the Timmins teaching teepee the previous year. These students were keenly interested in learning about the First Nations, the Athabasca Chippewyan First Nation and the Fort McKay First Nation, whose traditional territories are home to the oil sands. The students wanted to know whether the communities welcomed or were hostile to the projects, given the centrality of water to Aboriginal culture (in addition to the universal concern for conservation of ground water) and its intensive use in extraction. From direct experience living and working in the oil sands, Thorley was able to share with students the divergent views of the two communities. Fort McKay First Nation, closest to the city and upstream from most development has a favourable opinion of industry: community members have negotiated agreements that have enabled them to secure good jobs at the mine sites and to establish successful businesses to provide ancillary services. In contrast, the community of Fort Chippewyan is further north, *downstream* from development. Although they too have built some ancillary businesses, equivalent opportunities for employment have not benefitted the more distant community, and there are allegations that poor health outcomes are the result of toxins (McDermott, 2014). There is yet no proof to the claims, and attempts to secure participation of all of the nearby First Nations in a comprehensive public health investigation have encountered multiple hurdles (Weber, 2013).

Learning objectives related to sustainable engineering require that both cognitive and affective domains be applied to problems that have social, environmental and economic dimensions. Richly detailed and compellingly presented case studies could have been used in support of our learning objectives, but visiting the area allowed students to experience directly the scale of operations, the boreal forest environment, and the distances between the city, the production sites and the Aboriginal reserves. Whereas their technical courses rightly emphasize the acquisition of knowledge and skills related to safely mining and processing this resource, this trip provided a unique opportunity for students to sense the ethical dilemma of downstream effects. The contrasting experiences and attitudes of nearby communities underlined for students the difficulty of ensuring that the interests of so many diverse stakeholder groups are protected. Those who participated in this field trip have realized that exploitation of unconventional petroleum reserves requires that intersecting problems be addressed. An important lesson for young engineers who may practice within Canada is that the Aboriginal peoples of the country are culturally unique and their perspectives on mining's impacts and benefits are diverse and contextual.

Fort McMurray's situation has been likened by social historians to that of a gold-rush town, while residents will argue that modern approaches to planning have ensured that the city's growth is conducive to maintenance of a healthy young population. This debate notwithstanding, "Fort Mac" exemplifies the paradoxes that surround the extractive industry. These include the fact that the oil industry is a major employer of both highly skilled and marginally skilled workers, with an appetite for human resources that can scarcely be satisfied, even though the unemployment rate in the country is 6.7% (Statistics Canada, 2014). In addition to local residents, industry depends on a huge transient workforce that flies in for three to six week blocks from as far away as Newfoundland. It generates much needed revenues for all levels of government from the Regional Municipality of Wood Buffalo, which is home to the city and its mines, to the federal government. In between, Alberta has developed a co-dependence on industry to fund increasing demands on provincial infrastructure (transportation, energy, education and health). The opportunity to earn money is almost without parallel in Canada (for example, truck operators with grade 11 educations easily earn over C$100,000) but the combination of fly-in camp lifestyle combines with high disposable income is correlated with drug and alcohol abuse, as well as creating labour shortages in other sectors. In Fort McMurray itself, housing demand outstrips supply while service jobs unrelated to the mines are overwhelmingly filled by "temporary foreign workers" (TFWs), mostly from the Philippines, who are indentured to a single employer for a period of up to four years (Bennett, 2014).

Next Steps—Continuing to Enrich the Undergraduate Curriculum

For a small department, its financial cushion notwithstanding, a critical decision is whether *Sustainability* will become a research as well as a teaching focus. It remains to be determined whether resources are available to support an interdisciplinary research program into aspects of sustainability, such as impacts on wildlife habitats and the effects of in-migration on incidence of sexually transmitted infections (STIs), gendered experiences of impacts, and other concerns that have not traditionally been a part of the mining curriculum. If the stand-alone sustainability course comes to be complemented by contextual discussion of issues within the technical curriculum, its evolution can take either of two paths: it can become the vehicle for a critical exploration of the philosophical underpinnings of sustainability: an economy predicated on growth, the environmental and social costs of unchecked consumption, inequitable distribution of impacts and benefits, the asymmetric political power of corporate and human interests and the ethical obligations of licensed engineers to participate in and inform public discourse about appropriate approaches to solve these problems; alternatively, the course can function as a practical knowledge (survey) course, enabling students to develop a more comprehensive understanding of the legal frameworks that bound their work. Given the number of jurisdictions and diversity of regulatory environments that students are likely to encounter during their careers, such an evolution would offer similar scope for critical reflection on mining practice, through an exploration of the interplay between expectation, aspirational commitment, and enforceable regulation.

The Graduate Certificate in Community Relations

A certificate program in Community Relations was launched at the University of Queensland (UQ) in 2006. With industry support in the form of both input into curriculum and financial resources to fund its development, the UQ program has enjoyed a healthy and steadily increasing enrollment from its inception, employment of graduates across the industry, expansion of opportunities for graduate studies, including development of diploma and master's level programs. To date, UQ has trained over two hundred field workers who liaise between local communities and mining companies.

Jeffrey Davidson was given the task of creating a similar program to support the adoption of more effective community relations practices by Canadian miners. The Queen's program, the GCCR, is modeled on UQ's successful template: a program of four courses delivered entirely by distance after an initial week-long intensive residential component. The courses introduce, respectively: Community Aspects of Mineral Resource Development, Community Development for the Mining Industry, Community Engagement and Mining and Mining Projects and Indigenous People; but there are some significant differences to the UQ program. Queen's is a *graduate* program, requiring potential candidates to hold a minimum bachelor's degree, and it has also been tailored to address the contexts in which Canadian mining companies operate. Because Canada's federal government is committed to large scale mineral development in the country's Far North and in northern Ontario's "Ring of Fire," and because mainstream public education continues to leave most Canadians ignorant of the country's colonial past and the consequent challenges faced by today's Aboriginal Canadians, it was determined that the program's course on Indigenous peoples needed to include substantial content on the unique history, culture and concerns of Canada's Aboriginal peoples—particularly the First Nations and Inuit peoples who are at the nexus of development.

Launched late in 2012, the part-time graduate program attracted twelve candidates. Of these, two withdrew for reasons of increased professional workloads, four graduated after one year of study (taking two courses per term), and six completed the program in 2014. An additional six students enrolled in 2013, with two graduating thus far.

The mandate of the program is to familiarize students with the issues that matter to communities, the political and historical realities that underlie some mine-community conflicts and to prepare graduates with current best-practices from the fields of social and community work to assess and understand community needs and aspirations and to effectively develop and present plans for mining development that will assist communities in achieving their goals. The ability to build respectful and mutually beneficial relationships in the context of diverse (possibly incompatible) world views, often compounded by a profound power imbalance among the parties (as is evidenced in remote, often poor indigenous communities that lack political power, and multinational resource companies that wield influence) is the tall order for which this program aims to equip students.

The week-long residential component begins with an acknowledgment by the Dean of the Faculty of Engineering and Applied Science that Queen's University is situated on the traditional lands of the Algonquin and Mohawk nations and Prayer for Good Minds, led by an Anishnaabek elder. The department is fortunate that several Aboriginal scholars and elders have provided advice on the structure and content of the program and have been generous in sharing the experiences and worldviews that shape communities' perception of and attitudes towards mining. Given mining's historic role in the colonization and oppression of many communities and indeed, diversity of opinion among Aboriginal communities about the cultural and environmental appropriateness of industrial scale resource extraction, participation in the program is a sensitive matter for Aboriginal leaders, and we are grateful that participating leaders have honoured us with their trust in our commitment to partnership and respect.

Instructors of the four courses that comprise online portions of the program facilitate workshops during the residential week. In the first year, Aboriginal scholars and community members talked about their culture and spiritual connection to the natural world, as well as about their frustration with Canada's land claims process and the Indian Act.[4] This was done in *sharing* or *talking circles,* a traditional approach to the creation of safe space in which to air grievances and resolve conflicts. Some of the sharing circles were visibly uncomfortable for students, most of whom were confronting the historical facts and legacies of colonialism for the first time. In a facilitated discussion after the experience, several expressed indignation that they ". . . were being treated as if we were responsible . . ." They used words like "unfair," and "bullying." The obvious discomfort they

[4] The community members who spoke to the students are not named here because many are still distrustful of the mining industry and participation in any activity that does not condemn mining can be perceived as disloyal.

displayed can be interpreted as evidence of a disruption to previously unquestioned assumptions—expectations around identity, acceptance and accountability. However, by the end of the week, it appeared that students had begun to feel “safe” again, as indicated by the effusive praise given in their evaluations of the residential experience, to the dialogue exercises they engaged in with lead instructor Pam Bourke. These face-to-face events initiated a process of critical reflection that would be scaffolded in the online learning activities, in which Bourke explored how the companion problems of assumptions about others and of ourselves impede our ability to be authentic.

Specialists from private sector consultancies, with backgrounds in social work and conflict resolution offered advice and shared proven methods for coming to understand communities. Academics taught students about the interplay of soft and hard law, and the evolving international understanding of the Rights of Indigenous Peoples and implications of broader adoption of its principles of Free, Prior, and Informed Consent (FPIC). They shared experience negotiating Impact and Benefits Agreements (IBAs) and reflected on assumptions and omissions that can lead to community disappointment and loss of trust. Senior management from some of Canada’s major mining companies and industry organizations explained how government regulations, corporate finance and frameworks for permitting constrain their decision-making. They offered guidance on how students can better understand these constraints in order to communicate the community relations plans to the boardroom and win board support.

Cranton (2006) contends that transformative learning, described by Mezirow, can be facilitated by the creation of situations that disrupt intellectual comfort and complacency. For these disruptions be effective, educators must provide supports that help students to arrive at new and expanded perspectives; but the journey’s work is down to the student. The learning activities in the GCCR courses serve to support exploration of alternatives to outmoded worldviews, offering new perspectives that may reconcile old assumptions with new visions. End of term evaluations confirmed that students had found the learning process to be challenging and provocative, but that they also felt they were “beginning” to “see things differently.”

We believe that the strength of this program as it evolves is its collaborative approach, bringing participants from stakeholder and advisory groups together outside the high-pressure context of a negotiation to permit a multi-layered and progressive dialogue. The second intake was smaller than anticipated, much smaller than could support the substantial costs of bringing specialists to Kingston for the week-long residential. The decision was made in 2013 to postpone the intensive component until the summer of 2014 when it is planned that the 2014 and 2013 intakes can be combined. This decision was not taken lightly since feedback from UQ (Bourke, in conversation, 2013) and from our own first cohort had confirmed both engagement with professors and fellow students and the provocative immersion in the issues as essential to the transformative value of the program (ahead of independent study).

This setback necessitated the revision of curriculum, adding introductory material to the front ends of all courses. Professors made greater use of multimedia to engage students in the discussion forums provided in the learning management system (LMS). Knowing that one of the reasons for the low 2013 enrollment was the industry downturn, which resulted in across-the-board cuts to professional development budgets, we sought to work more closely with industry to ensure that they would see the value in supporting the GCCR program. We convened an Advisory Meeting during the fall of 2013, inviting senior representatives from the CSR and CR divisions of Canadian major miners, government agencies and the Assembly of First Nations (AFN), a major Aboriginal policy and advocacy organization. We also invited faculty from departments whose expertise is relevant to responsible mining and whose research includes work with communities affected by mining.

We were pleased with industry's willingness to advise us. Almost every company that we invited sent a senior manager or VP to the meeting, some travelling thousands of miles. The agenda for the day included three presentations on CR from the perspectives of a senior VP, a site CR manager and a field CR consultant. Bob Rae, a respected senior politician (former Premier of Ontario and former leader of the Liberal Party of Canada) who is currently the chief negotiator for the Matawa Tribal Council, an umbrella organization representing the interest of six First Nations whose traditional territories cover the mineral-rich Ring of Fire, delivered a keynote address that infused the day's work with purpose. Rae is a passionate voice for reconciliation of Canada's peoples after the violence of colonization. He also promotes the unique opportunity afforded by appropriate mining development to radically alter Canada's relationship with Aboriginal peoples. To do this, he argues, mining projects must look to a partnership model that sees decisions taken in collaboration with affected communities. A compelling speaker, with a vast knowledge of Canadian legal history and great respect for Aboriginal people, Rae's vision of mining's potential as the basis for healthy thriving communities underlined the importance of the GCCR program's objectives and added to the energy and enthusiasm among the participants.

After reviewing the program objectives and structure, participants were led in a gap analysis of the curriculum. This exercise took the form of facilitated small group discussion—where groups were constituted to include at least one member from each main stakeholder group: Aboriginal peoples, government, academia and industry, consultancy/NGO—around the following questions:

1. Does the program have the correct focus? That is, does it address needs?
2. Who should be targeted for participation?
3. How do you see the program leading to certification? (Canada does not have any industry standard for the certification of community relations personnel.) How should we plan to accommodate this in the intermediate and mid-term?
4. Are there additional or better ways to deliver the program's objectives? Feel free to consider all options.

The results of the exercise were made available in December 2013. There were five main recommendations:

1. Consider laddered credentialing (GCCR certificate as step towards a Master's).
2. Consider reducing the size and weight of the modules and increasing their number to allow students to select areas of specialty.
3. Improve marketing by developing a concise program purpose statement, articulating WHAT the program's aims are and WHO the program is designed for.
4. Balance the theoretical with the practical (Increase use of simulation and case study).
5. Increase the potential for capacity-building (sharing with colleagues).

The university has now granted permission for GCCR graduates to proceed to a master's degree (an M. Eng.) by taking four additional graduate courses. The development of additional distance offerings has begun and the first of these was offered September 2014.

The raw feedback data also emphatically showed a desire for short modules, particularly offered closer to head offices. As a result, the department is offering a two-day Seminar on Community Relations February 27-28, 2015.

The Seminar on Community Relations

The *Seminar on Community Relations* is conceived of as an annual event focusing on a single theme critical to supporting constructive community relations. The inaugural theme is Resettlement—a highly complex and contentious issue, particularly in the developing world where land tenure laws have not protected the rights of pastoralists and nomadic peoples. With participation of respected experts such as Luc Zandvliet and the staff of rePlan, the seminar promises to introduce participants to the competing agendas that collide when mineral projects are planned for areas where subsistence farming is practiced. The intensive week of the GCCR program has been reconfigured to benefit from synergy with this event. It will now begin with students joining industry practitioners at the seminar before spending three additional days immersed in dialogue training and becoming acquainted with their professors and the LMS. It is our hope that the seminar will address industry's request for short modules and serve to demonstrate the value of investing in the GCCR or M. Eng.

NEXT STEPS

Achieving social equity and environmental sustainability will depend in large measure on two factors: responsible agriculture and responsible mining. We have argued that access to metals is critical to increasing social and economic equity, but also for addressing environmental pressures resulting from past practices and a population of more than 8 billion. Access to the products of mining is highly correlated to standard of living—current levels of inequity would seem to imply that exploitation of the planet's mineral resources will be required for some time to come, even if the affluent countries of the global North can be persuaded to reduce their own consumption and increase percentage of materials recycled. The materials that comprise the bulk of water and waste systems, for example, are metals and plastics, both products of the extractive sector, with large volumes of aggregates used alongside. Thus, if we consider such a basic human right as clean water and the health that it protects, we *must* come to terms with our reliance on water-intensive activities such as mining. Add to this, the role of mined materials in the infrastructure of clean and renewable energy and transportation systems and telecommunications (which, as illustrated by events such as the Arab Spring, play a role in extending democracy and human rights throughout the world). It becomes evident that engaging constructively with mining's problems is our only ethical course of action.

What of the corporate nature of the extractive industry? Industrial scale mining is a multi-billion dollar sector operating globally. Critics are highly skeptical of the potential for the industry to bring lasting benefit to the less powerful citizens of the world, and some dismiss industry's progressive policies as mere *green-washing*. Such criticism serves a purpose, ensuring that attention remains focused on practices that do not serve society as well as they might, and that alternate conceptions of a healthy and just society are considered. The students who are currently studying mining engineering at Queen's are preparing for careers in which they are likely to work for and may eventually become directors of corporations engaged in industrial mining. Even at the pinnacle of their careers, they are unlikely to be able to alter the corporate imperative to "make money," but as engineers, there is broad scope for them to influence decisions about *how that money is made*. It is thus essential that we instill the values and impart the skills that will enable graduates of our programs to direct their corporations' economic and political influence towards support for environmental and social justice objectives.

The fruits of curriculum change are slow to ripen, but when today's graduates progress to the boardroom, we expect to see an acceleration of the pace of the adoption of enlightened corporate policy: that which embraces a broader conception of partnership—bringing the benefits of mining to affected communities in forms that are culturally appropriate, continuing to make progress in lessening environmental risks, and effective rehabilitation of lands after closure.

In the words of Tye Burt, the former President and CEO of Kinross, "The mining industry needs more engineering graduates with the skills to meet the challenge of responsible mining. That includes the ability to understand the expectations and aspirations of communities where we work, and to find 'win-win' approaches that support business objectives while also making a positive net contribution to the long-term economic and social well-being of the community" (Kinross, 2007).

The process of curriculum revision and renewal, the weaving of contextual elements including historical, political, cultural and environmental concerns throughout the technical curriculum requires considerable collaborative effort and will take time to be fully realized, but faculty members are committed to preparing our graduates for a world that will depend upon more socially-engaged and competent engineers.

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BOOK REVIEW

Engineering Ethics: Challenges and Opportunities

by W. Richard Bowen, Springer, 2014

Reviewed by George D. Catalano, Professor of Bioengineering, State University of New York at Binghamton, catalano@binghamton.edu

Bowen's book on engineering ethics is a breath of fresh air for those of us who have argued for many years that the engineering profession needs to dramatically widen its sense of ethical responsibility to include issues of war and peace, as well as social justice. The book makes an important contribution to the changing notion of ethical principles in engineering and engineering education. This review highlights several areas that are incredibly important as engineering moves forward in the 21st century. Also references are made to several concerns I have concerning the completeness of the text.

Using the notion and importance of communities in developing ethical principles certainly makes a strong case for the broadening of the engineering profession to include violence or its prevention and the nurturing of justice. Yet the notion of peace is, I believe, much more than the absence of violence. Perhaps it might be useful for the author to more fully elaborate both negative and positive peace and how engineers may figure in both. This would seem to only strengthen the author's assertion that the pursuit of peace is an ethical responsibility for all engineers. ***Approaches to Peace: A Reader in Peace Studies*** by David P. Barash and ***Peace: A History of Movements and Ideas*** by David Cortright might serve as useful references in further discussing negative and positive peace.

Virtue ethics certainly offers one useful way to examine ethical responsibilities in the engineering profession. I would suggest again, for the sake of completeness, that other paradigms of more recent origin might be helpful in strengthening the argument for a broader ethical responsibility. Our understanding of the natural world and the Universe has changed a great deal since the times of Aristotle. Now we speak of complex systems and even chaotic systems. A question worth exploring might be how does the "new physics" affect our sense of ethical responsibility? If a system is chaotic, does it even make sense to speak of ethics? Two sources that deal with such issues is ***The Natural Contract (Studies in Literature and Science)*** by Michel Serres, Elizabeth MacArthur and William Paulson and ***Chaos and Order: Complex Dynamics in Literature and Science (New Practices of Inquiry)*** by N. Katherine Hayles.

The issue of engineering and its part in development for me seems particularly difficult. It is not clear to me as to what might be the end goal for development, that is, development from what to what exactly? Is it our ethical responsibility to help transform all cultures to a slight different version of our very own? Such questions point to the very definition of technology especially a technology that is based on Western values. It seems that there are other views or visions of technology that might be useful to consider if we are truly to broaden the ethical responsibility of the engineering profession. Particularly many indigenous cultures today are very wary of being transformed into societies which we in the West, under the dominant patriarchal view, deem as the goal. Let me point to a technology of the Native American cultures which comes forth from what they term as “Native Science.”

Certain elements of the “Native Science” paradigm are common to Western science while others go beyond the conventional framework yet there are fundamental differences. For example, “Native Science” does not view living systems reductively, but rather grants them full integrity and ontological standing. Such integrity and standing is likewise granted to the rest of the universe, in which everything is viewed as animate and having spirit. Secondly, the human being logically is in existential relationship to all domains of nature with corresponding responsibilities and as self-conscious agents must recognize their role and responsibility to assist in maintaining dynamic balances of the natural world through participation and renewal. Thirdly, the “place” must always be included in ethical decisions. Lastly, human actions should emerge from a source beyond individual motive, and instead be sanctioned through ritual and ceremony reflecting a larger spiritual world order. I would suggest that this science may lead to a very different understanding of ethical responsibly that we might have in the engineering profession.

In summary, I feel that Bowen’s text makes significant and tremendously important strides in challenging the engineering profession to broaden its sense of ethical responsibilities. My suggestion are made only to further strengthen his argument as I believe the profession is badly in need of movement towards a more realistic and responsible view of its role(s) in the world of the 21st century.

POEM

I am an Engineer who happens to be a woman who is Black

Stacie L. Gregory*

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Engineering I loved it, but it did not love me ***back.***
Is it because I am a woman or because I am ***Black***?
These are traits, by which I am ***defined***.
Labeled, placed in a box, I have been ***confined***.
I need to escape, I am ready to ***go***.
Who am I really? This I need to ***know***.

My intellect, my own abilities, I am beginning to ***doubt***.
To gain back self-worth, I must get ***out***.
Others too, sad to ***say***, will face this same dilemma, before graduation ***day***.
Is this degree worth ***it***? Am I the right ***fit***?
They will ask, before they finally ***quit***.

Give up on a dream, a path they ***took***.
Discouraged from *persisting*, simply because of how they ***look***.
Engineers we need more . . . *in the* ***USA*****;** this we hear the privileged ***say;***
as they push the "*other*" ***away***.

What will it take to get more Americans to ***innovate***?
Unconditional love? A little less ***hate?***
Recognition and acceptance that we are all ***great.*** Giving everyone a chance to ***participate****.*
Recruitment and retention . . . buzz words administrators ***speak***.
Yet their efforts are far too ***weak***.

Inclusion, acceptance**,** and diversity ***too***; but only for those who are most like ***you***.
Deny who I am. Ashamed of who I was born to ***be***?
Just to earn an engineering ***degree*** *and* to ***be*** doubted ***daily***.
Even by those with less education than ***me.***

Contribute to society & make a difference in this ***life***; have kids**,** get married**,** and become a ***wife***.
This is the choice many have ***mad*****e**; to avoid heartache if they had ***stayed***.
Stayed in a career, as an unwanted ***guest***; even when they have given their ***best***;
EXHAUSTED . . . so they decide to ***rest***.

Why so few? Why do they ***leave***? If I told you the truth, you would not ***believe***.
Yes, they had the ability to ***achieve***. Yet, what they needed, they did not ***receive***.
The freedom to be authentic and ***free***; a chance to exhibit their unique ***creativity***.
When all can agree that our differences make us **great**, this will give us the power to ***innovate***. Develop novel things, not just ***replicate***.

When everyone is allowed to join in the ***game***;
appreciated for not being the ***same***;
acknowledged as part of the ***team*** . . . *permitted* to live the American ***dream***.
If being an Engineer is a dream of ***mine***; include me, allow my light to ***shine***.

Recognizing my light will not cause yours to ***diminish***;
Instead it gives energy . . . helps you ***replenish***.
United, as one, working side by ***side***; giving each other permission to excel with ***pride***.
My chosen profession, I am teaching it how to love me ***back*** . . .
to accept me as an engineer who happens to be a woman**,** who is also ***Black***.

A poster encouraging women to pursue technology studies at University of Valle, Cali, Colombia. It reads: "If it's not appropriate for women, it's not appropriate. Women and technology." c. 2000. Some rights reserved.