**New Graduate Experiences of Learning Ethics and Equity in the UVic Undergraduate Engineering Program**

by

John Fagan
B.A., University of Victoria, 2006

A Thesis Submitted in Partial Fulfillment
of the Requirements for the Degree of

MASTERS OF ARTS

in the Department of Curriculum and Instruction

# Supervisory Committee

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# Abstract

This study listens to the contributions of recent graduates from the University of Victoria's Bachelor of Engineering Program, hearing their understanding of ethics and equity, and how they experienced learning this in the program. This is done with consideration of how their understanding and experiences might inform curricular and pedagogical improvements in the experience of learning ethics and equity. Using a case study of these participants and their experiences at the University of Victoria, this research takes into account the context of engineering education accreditation standards and the current state of the curriculum that the participants completed. The findings suggest that participants have a limited understanding of what ethics and equity means, both personally and professionally. Participants also found it difficult to recall learning occasions for ethics and equity. Recommendations are made for curricular reform, taking an integrated and across the discipline approach to teaching ethics and equity to undergraduate engineers.

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# Acknowledgments

I am sincerely grateful to the five participants who took time out of their professional lives to participate in this research for the purpose of refining engineering ethics and equity learning. I wish them every success in their professional careers as engineers.

Thank you to Dr. Kathy Sanford, my supervisor, for your support, encouragement and guidance. Your belief in my ability and potential, and your expression of the significance of this research has kept me motivated and encouraged. Thank you to Dr. Tim Hopper for helping me to understand how to conduct qualitative research in a manner that allowed me to effectively code and analyze the data.

To my Father and Mother, thank you for teaching me conscientiousness, integrity, determination, and humility. It is because of their influences that I care about ethical and equitable professional practice.

Finally, thank you to my partner Tersia for your patience, understanding, and support that allowed me to get through a long period of analysis and the intensity of the writing process. Namaste!

# Dedication

Ethics to me is fundamental to acting with integrity, and issues of equity become a lot more real when one is part of a minority, or a group that is different than the norms of society.

In agreement with Nelson Mandela, I believe that a central purpose of education is improving lives. Having spent the first half of my life living in Zululand, South Africa, and the latter half on Coast Salish Territory in Canada, my interest and thought is influenced by the philosophies of these two indigenous Peoples. The epistemology and ontology of the First Peoples of the American Pacific west coast suggests that when designing curriculum, we consider the impact we have on the next seven generations. In central/southern Africa I learned of *Ubuntu*, a Bantu ontology that reminds us that humans only exist as an individual self because of others and community, and that without you to know, I cannot truly know who I am. These approaches inspire me to contribute positively to my community, and care about the wellbeing of future generations.

I dedicate this work to those who are minorities or different, and courageous enough to challenge the norms and mores of society in pursuit of positive change towards a society that values diversity.

# CHAPTER 1: INTRODUCTION AND CONTEXT

## Overview of the Thesis

The way professionals assess appropriate and ethical action can have a far-reaching impact on their business and career success. For this reason, professional associations provide guidelines (in their codes of ethics) for standards of ethical action, and regulate the licensure of their profession. This study considers the ethics and equity learning of graduates from the University of Victoria's Bachelor of Engineering program, and how this learning impacts their ability to make ethical choices in their professional capacity. In this introduction, I discuss the motivation behind my research and my interest in how Professional Engineers learn ethics and develop skills in professionalism. In addition, I provide contextual information about my own role as a Career Educator with the Faculty of Engineering at the University of Victoria (UVic). My research is interdisciplinary by virtue of the curricular consideration of the teaching and learning of ethics and equity within the UVic Engineering program. Furthermore, my research is motivated by a decade of experience in the abovementioned role, which has led me to conduct research in the Faculty of Education, Curriculum and Instruction Department. First, I will begin with some context.

In a world where knowledge is so readily available on the internet, some educators are realizing that teaching and instruction must shift to keep up with the dynamic requirements of learning in the 21st century. Most of the engineering coursework utilizes scientific facts and formulas, however engineering is an applied science, and much of the learning is experiential in nature, with labs being a large part of the learning experience. This type of learning involves reflecting upon one's own actions

in order to learn how to act in future situations. This is germane to professional programs from the perspective of practice and the ongoing professional development required to keep up with advances; and for engineering, technological advances are particularly important. It is no longer enough to graduate conversant engineers with the ability to apply knowledge; today's engineers must navigate an integrated world of software, mechanical, electronic, and social labyrinths in an ever-increasing complexity of a technology-rich society. Effective engineers are of course competent in their technical as well as their interpersonal skills, but to succeed in today's workforce an engineer will need to integrate their technical and social abilities into an intentional expression of their professional identity in order to thrive in a complex 21st century workplace. How is this achieved? A rich curriculum with theoretical and applied learning opportunities will develop these abilities for professional engineers graduating with a bachelor's degree. This qualitative study examines how five new-career engineers have been prepared for the ethics and equity complexities of contemporary occupations, technologies and societies in their university Engineering programs.

This case study explores new graduates of the Bachelor of Engineering (B.Eng) program that is accredited by the Canadian Engineering Accreditation Board (CEAB). This accreditation requires that the program delivers learning outcomes delineated in the CEAB's 12 Graduate Attributes (Engineers Canada, 2016).

## Situating Myself as Researcher/Practitioner

In my career educator role with UVic Engineering Career Services, I have worked with many passionate young Engineers since 2008. During this time, I have witnessed students beginning their journey, some more social and communicative than others, but all sharing an experience of hope and establishing new friendships, creating new

networks. Engineering students have a heavy technical course load and work hard to develop the skills and knowledge required for their first work experiences engaging as an engineer. It has been my experience in advising Engineering students that they tend to focus on building the mathematical and technical competencies required for their work but often underestimate the importance of interpersonal skill development needed for professional success in the 21st century.

The first year of the B.Eng program at the University of Victoria is common to all engineering disciplines. Upon completion of two academic semesters of foundational courses, the students choose their specialization in mechanical, electrical, civil, biomedical, computer, or software engineering for the remainder of their degree. At this stage I coach students through the decision-making process, providing resources, information on labour market projections, and career advice about their specialization, guiding them towards the mandatory Co-operative Education component which includes at least 16 months of applied technical work in the student's chosen field. During this time, I work with students in group workshops and individual appointments, coaching them in communication skills, employability skills and developing their understanding of the professional behavioural standards (professionalism) expected in the workplace as a Professional Engineer. Provincial regulatory bodies such as Engineers and Geoscientists of British Columbia, under the guidance of the national regulator Engineers Canada, define these standards. In fourth year, after students have completed their academic and co-op work terms, I once again work with them on professional career planning. Here we together prepare for their Engineer in Training (EIT) registration and explore sectors and industries where their skills have particular value. I have found that every individual experience is unique, but all students share the common challenge of balancing their

mathematical and scientific abilities in a labour market where social and interpersonal skills are proving more valuable and necessary than they imagined (LinkedIn Learning Solutions, 2017, p. 8).

In addition to working with students in the career educator capacity, I participate in the design, development, and teaching of career readiness curriculum, introducing the competencies required in professional practice. In 2010, I led a committee in rebuilding *Engineering 020: Introduction to Professional Practice*, which I taught for three years. This course, now titled *Engineering 130: Introduction to Professional Practice*, continues to evolve with an enrolment of 600+ students per year, providing a foundational understanding of topics such as ethics, communication, social responsibility, and work search skills. In 2011, I collaborated with Dr. Kin Li to build and teach *Engineering 330: Professional Career Planning and Engineering Leadership*. This course (designed for senior undergraduate students who have completed one year of work experience) develops capabilities in leadership, project management, mentoring, and professional career planning. A unique aspect of Engineering 330 is the inclusion of a mentorship program embedded in the course work, where participants coach first year students who are identified as at risk of dropping out.

It is through participation in these projects that I learned of the CEAB's engineering undergraduate program accreditation. Due to the social responsibilities, inherent with designing and building today's technologies, Engineering is a regulated profession in Canada, and requires that graduates of a B.Eng. develop adequate professional skills (expressed as graduate attributes) before gaining access to the professional licensure process as a newly graduated EIT.

My experience of building and refining curriculum, while also teaching these courses to many engineering students, has alerted me to the attitudes held by new graduates towards the social issues of diversity and ethics. The limited comprehension of ethical dilemmas and underdeveloped interpersonal communication skills demonstrated by many students has motivated me to consider where and how the teaching and learning of ethics and equity skills might be enhanced. Ethics is commonly considered a code of behaviour, or guidelines and rules for differentiating between right and wrong. These rules are often defined by a particular group for other members of that group, as there is no universally accepted set of such rules, meaning that equivocation can be a common issue in the mutual understanding of ethics. Equity often refers to fairness or equality, and for this study equity is understood as meaning both equality and fairness together. The realization that students found learning in these areas challenging led me to formulate my research questions in pursuit of gaining a learner's perspective on learning ethics and equity, articulated through the lens of my experience as a professional career practitioner with the UVic B.Eng. program.

## Research Questions

1. How do recent graduates describe their experience of learning ethics and equity in the UVic B.Eng. program, while making meaning of their professional work in terms of ethics and equity?
2. In relation to effectively teaching ethics and equity in the B. Eng. curriculum what can we learn from the experience and practice of recent graduates?

## Ethics, Truth and Reflection

With the proliferation of the internet and the availability of information and with data moving increasingly faster through networks, education is undergoing a transition or even a paradigm shift. The traditional approach of learning by focussing on the "what" of engineering education (and all education) is changing, and we are seeing a shift to focussing on the "how" and even the "why" of educational skills and knowledge. In the K-12 school system in British Columbia there has been a move to teaching critical thinking, collaboration, and communication to complement literacy and numeracy skills (Government of British Columbia, 2019). More reference is being made to multi-literacies and students are developing skills with video editing and web development as well as writing and arithmetic. Along with these multi-literacies comes the development of social and professional skills required to effectively integrate the technical and social knowledge in their work. Future engineering students will need to demonstrate a wider range of professional competencies, skills, and knowledge.

In his 2015 study, David Deming used a longitudinal analysis spanning 30 years to explain the importance of social skills in the workplace, showing how the labour market has increasingly rewarded social skills more than purely technical skills (Deming, 2017, p. 2). This need for social skills can be overshadowed by the corporate call for more students in science, technology, engineering, and math (STEM) required to fill the skills shortage created by rapid technological advances. Many of the companies I regularly communicate with confirm that they seek out engineers who are technically qualified but also socially adept, requiring effective communication and collaboration skills, as well as the ability to think critically when solving problems.

**Metacognition and reflection.**

I have learned from my own professional experience that for effective professional learning, development of a level of metacognition and reflective ability is vital as part of experiential learning in action. This realization was reinforced when I read the article "Engineers' professional learning: a practice-theory perspective", in which the authors express that "…learning is … more than the technical acquisition and transfer of knowledge, but a complex bundle of activities, that is, social, material, embodied and emerging" (Reich, Rooney, Gardner, Willey, & Fitzgerald, 2016, p. 366). This practice-theory perspective serves well for learning an applied science and preparing professional engineers for the complex problems they face in today's world. With professional engineers now addressing problems impacting large volumes of society who regularly use technologically advanced devices, the application of theoretical knowledge is a commonly required part of the Engineering profession. One part of a complex nexus of considerations is the ethical consideration of 'right' action in their professional work, and this is where my interest in ethics-learning for engineers finds significance in the professional formation process of engineers.

**T(t)ruth and perspective.**

Realizing the significance of reflection brought to my attention the importance of metacognitive ability that is increasingly required in the 21st century workplace. In a workplace where "truth" is not always what it seems, young professionals must navigate a quagmire of ethical ambiguity in a complex and competitive labour market. In today's business landscape the common use of hyperbole for marketing or political motivations, along with an emerging respect for non-binary perspectives, has seen the idea of "Truth" being challenged by the recognition that there are always multiple legitimate or non-

legitimate perspectives that inform a situation and need to be recognized as contributors to the dialogue. By being reflective and able to engage in a metacognitive self-assessment and situational awareness, students are better equipped to navigate the ethical ambiguity common to professional practice. This is why each course that I have built (and teach) includes weekly reflective questions. Students are asked to reflect on a given topic; for example, reflection on communication skills. They are required to express their perspective, receiving constructive feedback rather than a grade for their opinion. This curricular component is the beginning of 'learning-informed' reflective practice where students gain an improved awareness of their own attitudes and perspectives, forming foundations for their professional careers. By 'learning-informed' I mean that the learner responds to reflective questions which use information that includes an awareness of their own past thinking and behaviour as the data upon which to base their new learning and behavioural performance enhancement. Their own preconceived ideas on the topic, comments from others in the class, or anything from the information environment around them will inform their learning.

## Why Focus on Young Engineers in Training: Capabilities and Careers

Through a decade of work in engineering career development, I have gained an understanding of the career launching challenges faced by 21st century engineers entering the workforce. My observation from keeping in touch with alumni has been that engineers with a well-developed sense of professionalism and the accompanying skills (such as reliability, technical competence and ethics) tend to launch their careers more successfully and progress to senior positions in the current labour market. It seems that a young engineer's communication and negotiating skills are crucial to achieving a better salary for themselves in a highly competitive market. Keld Jensen, (in an article in

Forbes) mentioned a study saying that "[r]esearch carried out by the Carnegie Institute of Technology shows that 85 percent of an individual's financial success is due to skills in "human engineering," their personality and ability to communicate, negotiate, and lead. Shockingly, only 15 percent is due to technical knowledge" (Jensen Keld, 2012). While Jensen does not support this claim with a reference, there is academic literature on the social and emotional development of engineers that does support the significance of this aspect of professional development for Engineers (Felder & Brent, 2013). So, the development of social and interpersonal skills will assist in career success and also seem to have an impact on the ethical decision making of a young professional – an Engineer in Training (EIT).

## Language Matters! Soft Skills or Professionalism Skills

How an engineer talks about their professional work creates the dialogue that carries the professional practice, allowing them to discuss their best practices and share insights with one another in the workplace. Their professional dialogue is also closely linked to choices and priorities (those things they find important), which in turn form the foundation of their ethics and moral decision making. Soft skills are understood as connected to character and personality (both very idiosyncratic traits) and not testable by achievement tests, but still predictive of life and career success (Heckman & Kautz, 2012). Communication is an example of an area of competence often referred to by engineers as a 'soft' skill, yet effective written and verbal communication are essential elements of professional engineering work.

My experience of working with engineers, engineering professors and my involvement in engineering education research has afforded me many occasions to hear the term 'soft skills' from engineers who are preparing for an interview or conference. For example, the

first-year Design and Communication courses at UVic use an integration of design principles and communication learning, with applied team based design projects, to teach the CEAB's Graduate Attribute number seven "Communication" and attribute number four "Design" (Engineers Canada, 2016). Using the term 'soft skills', I believe risks diminishing the meaning of skills such as communication, teamwork, and social skills by framing them as "soft" or easy as opposed to the more 'hard' technical and mathematical skills being learned. I see this understanding of soft skills as influencing young engineering students who I have experienced believing that these skills do not require as much effort as technical skills do, ultimately leading to underdeveloped skills that are essential to their professional career success. It is often the educators and researchers themselves using the term "soft-skills" to describe the social and professionalism skills developed through their programs. While I appreciate the computer metaphor explanation of *hard*ware and *soft*ware, this tradition potentially lessens the engineering students' value of non-technical skills like communication, and professionalism. I believe that curriculum design could include more consideration of the development of professionalism skills, referring to them in those terms, highlighting their importance in mobilizing one's knowledge, and better equipping young engineering graduates to navigate professional practice.

**Workplace and generational shifts: the meaning of professionalism.**

In the past decade, the career development profession's literature has included discussion around generational variances, with commentary on the differences between Baby Boomer, Generation Xers and Millennials (Applebaum, Serena, & Shapiro, 2004) This discussion has morphed into one of competitive labour markets, along with the rise of artificial intelligence seeing automation threatening professional jobs in the future.

From a career development perspective, jobs are of course important for new graduate employment. It is, however, the meaning made and value development through collaboration, communication, and the development of critical thinking skills that will impact graduates' lifestyles as younger generations face increased competition for opportunities from larger pools of qualified candidates (RBC, 2018). These changes, along with the shift from priorities of one generation to another, are made more apparent by the rate at which technology is changing the world of work for professional engineers. The global reach of technological advances in today's very connected world means that engineers need an understanding of how their work impacts human flourishing or not, and this is an important consideration for the future of engineering education (Johri & Jesiek, Global and International Issues in Engineering Educatuion , 2014).

Professionalism is a term used many times in this study and therefore warrants clarification as to my understanding of the terms profession or professional. In the Guideline for the Practice of Professional Engineering in Canada, Engineers Canada (The national regulatory authority) define a profession this way:

> A profession is a learned calling which requires advanced knowledge, understanding, and abilities gained from intensive and specialized education, training, and practical experience. Members of a profession limit their activities to their areas of knowledge and experience, doing so out of commitment to serve and protect the public. Professional practitioners also ensure that their competence is maintained throughout their careers. Professions tend to be characterized by high levels of organization and regulation, yet their members participate in activities which are varied rather than routine, and typically require the exercise of discretion and judgement (Engineers Canada, 2012).

From this description of a profession it is evident (by the inclusion of *discretion* and *judgement*) that ethics can be seen as inherently part of a Profession or of acting professionally. This publication also defines a Professional Engineer, saying:

> As professionals, engineers individually and collectively commit to serve and protect the public in all their engineering endeavors. The responsibility of self-regulation also obliges the profession to ensure that only qualified persons practice engineering and that they do so with concern for societal and environmental needs, while maintaining responsibility to clients, employers, colleagues, subordinates, themselves, and the profession at large (Engineers Canada, 2018).

So, Engineering is a Profession that holds social responsibility, promising credibility, accountability and public trust that the professional engineer is qualified to do the work they are doing. This close connection between being professional and being ethical inspires my interest in engineering ethics education and engineers' professional formation.

## Certainty, Ethics, and the Pace of Technology

The pace of technological innovation in software and machine learning has technology professionals, such as Bill Joy, writing articles like his 2010 *Why the Future Doesn't Need Us*, stressing the importance of humanity "surviving our technologies" (Joy, 2010). In this paper Joy raises a concern that is important to my study – the seductive nature of certainty – with his reflection on the binary certainty gained from using computers to solve problems. "The computer had a clear notion of correct and incorrect, true and false. Were my ideas correct? The machine could tell me. This was

very seductive" (Joy, 2001, p.5). I briefly mention Joy's paper because I see this as one of the difficult challenges facing young engineers who spend years learning from machines that right and wrong involves a search for certainty – which can indeed be reassuring – but the reality is that the social and professional landscape is rife with ethical ambivalence and uncertainty. Also, the world we live and work in has become reliant on technology and connectivity, and the pace at which social media can influence the thinking of large groups is impacting trade, politics, and business, raising the issue of digital literacy and the importance of teaching young engineers to think critically about the data they are consuming. There is exponentially more data available and with platforms like Facebook and Twitter, moral dilemmas are more public and more imminently presented to young professionals such as software and network engineers. For example, the decision to Re-Tweet the wrong thing can have far reaching consequences on a professional career. This increase in *pace* and *volume* of information means today's young engineers are pressed to conduct ethical reasoning at a *pace* previously unseen. This increase in the pace required of ethical decision making undoubtedly has implications for educators considering how to best teach ethics and ethical reasoning in professional programs. Navigating a reliance on certainty in an ever faster paced social and digital world not only challenges young professionals' ethical reasoning, but also adds work-life balance stressors that can impact an individual's health and chances of success.

What one believes is right or wrong is one's morality, and ethics is the acting out of these moral beliefs in the context of any given interaction. Ethics in engineering education can be seen as dealing with "questions of the moral ideals, character, policies, and relationships, of people and corporations" (Barry & Herkert, 2014, p. 673). I find that

this view reveals how connected ethics is with adequately negotiating the uncertainty that arises when dealing with others who disagree with us, particularly if we are expecting certainty in our social interactions. If an engineer is asked to compromise safety standards in design, the engineer is faced with choosing to follow a code of ethics and act with integrity – or to save money for their customer and thereby get more business. Because these business interactions are often filled with ambiguity, which requires navigating compromise between one's own agenda and that of others, I purposefully teach reflective practice to help students understand how important it is to be capable in dealing with uncertainty.

To better understand the experience of learning ethics in the UVic Engineering program, this study uses the narratives of five recent graduates gathered as transcripts of interviews/conversations with the researcher. The analysis of these transcripts reveals common experiences and focuses on participants' perspectives about learning ethics, providing a learner informed understanding of the B.Eng students' experience at UVic.

## Conclusion

In this introductory chapter, I have considered contextual information on engineering ethics education, such as the pace of technological advancement, and outlined features important to learning ethics, such as reflection and ethical reasoning skills; all considerations when framing the research questions for this study.

To consider effective ethics learning in an existing engineering curriculum, I believe that a broad view of curriculum, including teaching, technology, school culture, specialized content, and professional skill development of students, is needed. Engineering professionals have an inherent social responsibility, and while learning outcomes delineated in the CEAB's 12 Graduate Attributes (https://engineerscanada.ca/sites/default/files/Graduate-Attributes.pdf ) address the ethical component, current approaches to teaching and learning ethics (at the undergraduate level of engineering education at UVic) will be considered from how aligned they are with the requirements of a Professional Engineer (P.Eng) designation, and how well they prepare young professionals. In Chapter 2, I discuss the literature which influences my understanding of curriculum and apply this understanding to the review of literature on engineering ethics education, engineering professional development, and what it means to learn ethics and equity.

# CHAPTER 2: LITERATURE REVIEW

## Introduction

As a graduate student in UVic Faculty of Education's department of Curriculum and Instruction, with a background in mechanical engineering, philosophy and career development, my review of literature began considering the philosophers of education and curriculum theorists who helped me develop my understanding of education, curriculum, and ethics/equity learning. This chapter begins by looking at what curriculum means to me, as preparation for my inquiry into insights for curricular improvement as framed by the research question asking how the experiences of the participants might inform curriculum and pedagogy in engineering education. I then move on to an examination of relevant literature more specifically related to engineering ethics education, to gain a contextual understanding of the environment in which the B. Eng. participants learned ethics and equity; informing the focus of this study, as approached by the research question inquiring as to the participants' experiences of their education. This chapter utilizes suggested tasks for working with literatures from Barbara Kamler and Pat Thomson (Kamler & Thomson). A four-stepped process considers: 1) Mapping the field; 2) Establishing which literature is most pertinent to this study; 3) Creating a warrant for this research; and 4) Identifying what particular contribution this work makes to the field. This chapter concludes with a section clarifying how the literature contextualizes the undertaking of this research on recent graduates' experiences of learning ethics and equity while studying engineering at UVic.

## Philosophical and Theoretical Influences

Four of the theorists who have influenced my thinking in establishing and undertaking this research are the philosophers of education and curriculum: Michel Foucault, Paulo Freire, Nel Noddings, and Ted Aoki.

### Foucault: political and technical

French philosopher Michel Foucault takes a technical and political view of education, meaning that he considers educational systems part of the overall technology via which social systems gain control and power over the individual, intellectually, behaviourally and physically. Foucault explains the moral framework that he sees as inherent in educational systems – by the structure and rules imposed upon learners in a formal schooling environment – as a "Moral Orthopaedics" (Deacon, 2002). Foucault's perspective takes into account a normative impact of education, fundamentally connecting education and ethics, with education serving as a process for establishing prescriptive behavioural norms for a population (Foucault, 1975). While Foucault's is a very broad and generalized view of education, an ontological parallel can be seen in any professional program of study such as engineering, medicine, or law. Students are learning the technical competencies required of their profession, but are also learning how to behave as professionals, how to "be" doctors, lawyers, engineers – developing a professional identity of their own. It is this influence of societal context, school spirit, what it means to the participants to "be an engineer", where Foucault's views influence my broader thinking, motivating this research into the ethical aspects of an engineer's education.

**Freire: normative and transformative**

Brazilian theorist Paulo Freire views education in a similar way to Foucault in that Freire sees education as integral to power and societal shifts, however – whereas Foucault framed education as a mechanism through which the powerful exerted their power on the less powerful, Freire saw education also as a mechanism of liberation. Freire focused on education as offering the opportunity to lift one's self out of poverty and gain power through education. Freire's *Pedagogy of the Oppressed* helps us see that there is no neutral education. Education is either normative, influencing learners to understand societal norms and how to follow them, or it is transformative in that it teaches the knowledge and skills required to raise one's consciousness of the participation required in transforming one's world (Freire, 1970). Freire's idea that education cannot be neutral inspires me to contemplate the learning of ethics and equity in an engineering undergraduate program, and how this learning *intentionally* impacts a professional engineer's ability to effectively navigate ethical dilemmas in conducting their professional work.

**Noddings: relational, and the ethics of care**

The moral development work of Lawrence Kohlberg, which uses a staged based development model, has been thoroughly challenged by scholar Carol Gilligan for being gender biased and not inclusive of considerations of sentiment or moral feelings (Kohlberg & Gilligan, 2014). Nel Noddings, a renowned Feminist theorist in education and ethics, in her Caring: A Relational Approach to Ethics and Moral Education, continues Gilligan's work, and brings the focus of Virtue Ethics and the ethics of character into the modern literature through a discussion of relational ethics (Noddings, 2013). Noddings' approach to ethics inspires a new way of looking at ethics rather than

the traditional duty based, consequentialist and utilitarian standards – an ethics that considers human relations and context, and seems to be a lot closer to the experiences of ethical decision making in the lived world. Noddings ideas asks us to consider ethical learning opportunities in an engineering undergraduate program and consider what other factors (besides the technical course syllabus) can impact the effective learning of ethics and equity – thus informing (to some extent) the analysis of how my participants talked about their experience of learning ethics and equity at Uvic Engineering. Noddings Ethics of Care is also a reminder that the Faculty of Engineering is a community of Faculty, Staff, and Students, and modelling professional and ethical behaviour – showing that we care – is central to learning ethics and professionalism.

**Aoki: holistic integrative curriculum**

The ideas of a fourth theorist, Ted Aoki, a Japanese Canadian, helped me to better understand the potential of holistic multifaceted resource curriculum in researching educational experiences. Aoki uses the terms "curriculum-as-plan" and "curriculum-as - lived-experience" to describe his idea of balancing one's consideration of both and "…dwelling in the zone…" between them (Aoki, Pinar, & Irwin, 2004, p. 159).

I have appreciated the privilege of teaching curriculum that I built and using that experience to learn and improve for the next time I teach the same course, with a new unique set of students. The plan may be very similar from one semester to another, yet the personality of the students and the social dynamic of the group will always change. This personal experience helped me to better appreciate Ted Aoki's meaning, and to remember that human relationships play an important role in learning, just as they do in ethics.

## Curriculum Defined

In this research, I use a comprehensive and inclusive view of curriculum as is evident from the explanation of the four theorists influencing my outlook. To use the term *curriculum* in a way that incorporates my own experiences, I searched for an inclusive and broad definition of curriculum as a lens through which to look at ethics education in engineering. The following, from the United Nations Educational Scientific and Cultural Organization (UNESCO, 2016), is a definition that comprehensively covers the social and ethical reach of curriculum in the 21st century education landscape.

> Curriculum is a systematic and intended packaging of competencies (i.e. knowledge, skills and attitudes that are underpinned by values) that learners should acquire through organized learning experiences both in formal and non-formal settings. Good curriculum plays an important role in forging life-long learning competencies, as well as social attitudes and skills, such as tolerance and respect, constructive management of diversity, peaceful conflict management, promotion and respect of Human Rights, gender equality, justice and inclusiveness. At the same time, curriculum contributes to the development of thinking skills and the acquisition of relevant knowledge that learners need to apply in the context of their studies, daily life and careers. Curriculum is also increasingly called upon to support the learner's personal development by contributing to enhancing their self-respect and confidence, motivation and aspiration (UNESCO, 2016).

The breadth of this definition accommodates the social and ethical learning that is becoming more important in engineering education, where social and technical problem-solving skills are essential in navigating an ever more technologically augmented world

(World Economic Forum, 2018). The processes of applying technical knowledge in a dynamic complex social system can leave recent graduates feeling competent in scientific facts, but lacking the required practice of skills in professionalism, which is essential to applying this knowledge in real-world situations through work experience and internships (Besterfield-Sacre, Cox, Borrego, Beddoes, & Zhu, 2014). Despite these experiential learning opportunities, many students I have coached (individually over the past decade) expressed that communication skills, interpersonal skills, and the ability to articulate their ideas to others, were areas of development they found most challenging.

## Understanding Engineering Education

For an understanding of how ethics education forms a part of engineering education, my early literature searches included perusing a collection of engineering education (Canadian, American and European) journals' editions across a range from 2012 -2018. A 2014 publication that has assisted in developing a comprehensive understanding of the history and state of engineering education for this study is the Cambridge Handbook of Engineering Education Research (CHEER) (Johri & Olds, Cambridge Handbook of Engineering Education Research, 2014). This book covers a scope of topics pertinent to any research considering engineering education. Of particular interest for this study is Part Six, *Cross-Cutting Issues and Perspectives*, Chapter 33- Engineering Ethics (pp. 673-692), which provides an overview of the curriculum, assessment, and pedagogical methods used in teaching engineering ethics over the past 50 years (Johri & Olds, Cambridge Handbook of Engineering Education Research, 2014). This literature was helpful in establishing a foundational understanding of the approaches taken by engineering educators.

**Ethics in engineering education**

Engineering education as an area of research is a relatively young field, with the first references originating in the early 1900's when the first national societies were established (Petroski, 2008). Given the technical nature of engineering work it follows that much of the research around engineering pedagogy is centered on scientific, technical and applied science learning. Johri and Olds, the editors of CHEER, provide a map of the range of areas within engineering education research. It is noteworthy for this study that the section which houses the chapter on Engineering Ethics is called *Cross-cutting Issues and Perspectives* (in engineering education *research*) (Johri & Olds, Cambridge Handbook of Engineering Education Research, 2014). So, Ethics is considered a *Cross-cutting Issue* within engineering education – implying that it links other aspects of engineering education such as Design, Communication, and Problem Analysis. This implication is pertinent to this study because the research questions seek to find ideas for curricular enhancement from the views expressed by the participants. Current education practices (not only in engineering) commonly use a course focus, with an accumulation of discrete courses adding up to successfully completing a program.

Two well accepted textbooks used in teaching engineering ethics are worth mentioning at this point in order to illustrate common approaches to ethics learning in engineering education. The first, Martin and Schinzinger's (1996) *Ethics in Engineering* is descriptive in its approach, defining engineering ethics as "…the study of moral issues and decisions facing…engineers, and the study of related questions about the moral ideals, character, policies and relationships of people and corporations involved in technical activity" (Martin & Schinzinger, 1996, pp. 2-3). A second text, *Engineering Ethics Concepts and Cases*, offers a more prescriptive approach, describing engineering

ethics as "…concerned with the question of what standards in engineering ethics should be and how to apply these standards to particular situations…helping to promote responsible engineering practice" (Harris, Pritchard, Rabins, James, & Englehardt, 2000, p. 26). This text is clearly pointing to the ethical standards required of registered professionals and demonstrates a link between learning engineering ethics and the professional application of that learning in the course of professional practice. "The study of engineering ethics is often closely tied to the notion of professional responsibility" (Barry & Herkert, 2014, p. 674). Philosopher Michael Davis indicates that professional ethics is integral to professional practice, asserting that "[p]rofessional ethics is as much a part of what members of a profession know – and others do not – as their 'technical' knowledge. Engineering ethics is part of thinking like an engineer" (Davis M. , 1999). Davis suggests that the four goals of engineering ethics education are: 1) *increased ethical sensitivity*, meaning a raised awareness of the ethical nature of work that impacts human flourishing; 2) *increased knowledge of standards of conduct* – involving an understanding of how to put codes of ethics into practice through an ethically mindful conducting of their professional duties; 3) *improved ethical judgement*, which rely on moral maturity and ethical reasoning skills; and 4) *improved ethical willpower* constituting the ability to make sound ethical judgements and act ethically when needed (Davis M. , 1999). These four goals do (to some degree) address the requirements of developing the Canadian Engineering Accreditation Board's graduate attribute number 10, in "developing one's awareness and understanding of ethics in engineering" (Engineers Canada, 2016). These perspectives on engineering ethics education all point to the application of ethics as part of the competency of a practicing professional engineer. Most pertinent to this study is the consideration of ethics

education in engineering undergraduate curriculum, insofar as it builds a foundation for the level of professional ethics required for professional licensure as a Professional Engineer (P.Eng.) in Canada.

## Pedagogy and Assessment in Engineering Ethics Education

The Engineers and Geoscientists of British Columbia (EGBC) Code of Ethics states that engineers should only "undertake and accept responsibility for professional assignments…when qualified through training and experience" (EGBC, 2016). This section of the EGBC Code of ethics is mentioned in order to consider the qualification required to teach engineering ethics. Barry and Herkert (2014) note that the "preparation of faculty to comfortably engage in engineering ethics instruction remains one of the biggest challenges facing engineering ethics education" (Barry & Herkert, 2014, p. 679). Newberry (2004) notes that most "current engineering faculty members are products of the admittedly ethics-deficient undergrad engineering educational system" (Newberry, 2004, p. 349). So, while "…a background in philosophy and engineering might make an individual well prepared to teach engineering ethics, a well-prepared instructor from history of science…, technical communication, science and technology studies, and so forth could be equally qualified" (Barry & Herkert, 2014, p. 680).

So, Barry & Herkert (2014) see the basis for successfully learning engineering ethics as the learner's moral development and ability in moral reasoning, saying that many "… forms of assessment in engineering ethics specifically evaluate the notion of moral reasoning…" and many of the assessment tools used are based on Kohlberg's moral development theories (Barry & Herkert, 2014, p. 680). While this study has previously discussed (in the section on Nel Noddings) the problematic nature of Kohlberg's tool, due to gender bias in the choice of his subjects, his moral assessment

tool is mentioned here because it has been used at many universities in assessing engineering ethics learning – and the stages of development model has influenced the development of more recent assessment tools (Kakkori & Huttunen, 2010).

Kohlberg's (1981) theory of moral development is based on the idea that individual's progress through six stages of moral development which proceed through three levels from, an egoist oriented pre-conventional stage, through a more relational conventional stage, to a post conventional acknowledgement and understanding of the importance of basic social contracts. The moral reasoning assessment tool created by Kohlberg is known as the Moral Judgement Interview (MJI). This assessment tool scores participants based on the relation between their responses to dilemmas and the stages mentioned above. Barry and Herkert (2014) note that this assessment tool requires considerable training for the facilitator and reference to an 800+ page scoring guide, making it impractical for assessing large groups of undergraduate engineering students. More recent assessment tools are paper based and allow for bulk computerized marking. These include the Defining Issues Test (DIT); the Sociomoral Reflection Measure (SRM); and the Test of Ethical Sensitivity in Science and Engineering (TESSE) (Barry & Herkert, 2014, pp. 680-682). These assessment tools are used to assess the learner's ability to apply their ethical learning in a measurable case based process. None of these assessment tools are currently used in the engineering program at the University of Victoria. The mandatory ethics class *ENGR297: Technology and Society* takes a broader view of ethics as pertaining to technology and its impact on society.

**Ethics and equity in Canadian engineering education**

In Canada, the Canadian Engineering Accreditation Board (CEAB) establishes and prescribes the standards for curriculum in engineering undergraduate education. The

CEAB is a division of Engineers Canada, which also oversees provincial regulatory bodies such as Engineers and Geoscientists of British Columbia (EGBC). The CEAB expresses their 12 required graduate attributes in the form of learning outcomes, and the responsibility for integrating these into the curriculum is placed on the individual universities and Engineering Faculties seeking accreditation. For each of the 12 graduate attributes the institution being accredited is required to provide: 1) a set of indicators specifically describing the abilities expected of students to demonstrate each competency; 2) a curriculum map describing where attributes are developed and assessed within the program; 3) a description of how the indicators will be assessed; and 4) an evaluation of student performance relative to program expectations (Kaupp, et al., 2012).

In order to gain a broad understanding of the areas within Canadian engineering education, I reviewed the CEAB accreditation requirements as detailed on their website (https://engineerscanada.ca/accreditation/accreditation-resources). I also reviewed the Canadian Engineering Education Association's (CEEA) 2012 conference proceedings, which included a number of papers discussing the 12 Graduate attributes and how different institutions were mapping the attributes, outcomes, and assessments (Engineers Canada, 2018). In my literature search I realized how ethics learning in engineering education is only a small part of the many varied and mostly technical proficiencies taught, which are of course beyond the scope of this study.

The Journal of Engineering Education Research (JEER), published by the American Society for Engineering Education (ASEE), dedicated the entire April 2014 edition to "The Complexities of Transforming Engineering Higher Education" (JEER, 2014). Because I am interested in professional learning in engineering programs I also considered labour market information and sector/industry trends found on sites such as

Engineers Canada (Engineers Canada, 2015), or Engineers and Geoscientists of British Columbia (EGBC) (EGBC, 2017). This type of information is mostly gathered and archived by economists, industry associations and federal or provincial governments in Canada. As such, it is often framed with political and economic biases and cannot be acknowledged as academic literature. When, however, looking at labour market predictions and professional outlooks it is more common to find this grey literature than any available academic studies, which is why I include consideration of these types of reports in undertaking an academic as well as professional view of literature pertinent to this study.

In Chapter 1, this study cited the CEAB's 12 graduate attributes required of accredited Canadian Bachelor of Engineering Programs. These are a guideline for curricular planning and continuous curricular improvement for engineering programs across Canada. It is significant that seven of the 12 CEAB attributes (see Appendix 3) are of a professional and interpersonal nature (rather than scientific or technical), and while they can be tangentially developed by undertaking technical course and lab work, it will be through interpersonal interaction, experiential education, and reflection, that this knowledge will be intentionally developed, and integrated into the individual's existing web of knowledge (CEEA, 2013). From the Engineers Canada website, is apparent that attributes one through five have a clearly technical base (like *Engineering Knowledge*, and *Problem Analysis*), however attributes six through 12 are decidedly less technical or even professional in nature (like *Ethics and Equity*, and *Life Long Learning*) (Engineers Canada, 2016).

This study focuses on graduate attribute number 10: *Ethics and Equity*. Much of the research and many participant comments center on ethics without giving issues of

equity the same weight. At this point a fundamental understanding of the use of the term *equity* in this study is warranted. In this research, from the 12 graduate attributes of Engineers Canada, *equity* (Engineers Canada, 2016) is taken to mean equitable consideration of others despite their physical or other characteristics, equal opportunities in the workplace for all no matter their gender, orientation or age. For this research equity includes fairness and is more than equality – but equality and fairness interconnected.

### Ethics and equity education at UVic Engineering

The Engineering office at UVic provided me with information regarding accreditation for ethics and equity learning. The Accreditation Analyst, who collects and manages accreditation data, provided me with a robust understanding of how UVic Engineering approached accreditation with the CEAB, including curriculum mapping and indicators for graduate attributes. Each graduate attribute is expressed in measurable and documented description of requirements for students to be considered competent in the respective attribute. This is conducted by using the curriculum map and assessing courses for their contribution to coverage of a specified attribute. From the table expressing these indicators for UVic's Engineering program's assessment of attribute 10, Ethics and Equity, (see Appendix 2), it is evident that while UVic's Software Engineering program offers a senior level ethics course, the rest of the indicators for ethics and equity learning rely on one dedicated ethics class (*ENGR.297: Technology and Society*), and two first year courses (*ENGR130: Introduction to Professional Practice; and ENGR120: Design and Communication II)* (McGuire, 2018). The mandatory second year ethics course – *ENGR297: Technology and Society* – covers a comprehensive range of ethical topics from ethical decision making to environmental, legal, economic, and cyber ethics, and is

assessed using quizzes, discussions and in-class tests. The two first year courses include a brief reference to ethics and equity, with the related curriculum content providing a basic understanding of codes of ethics and professionalism.

**Professional learning in engineering curriculum**

In Canada, practicing Professional Engineers are required to achieve and maintain their Professional Engineering (P. Eng) designation. This involves spending up to four years as an Engineer in Training (EIT) before writing the comprehensive Professional Practice Exam (PPE), which focuses on the laws, professional practice, and ethical requirements of practicing as an Engineer in British Columbia and Canada. Continued Professional Development (CPD) is required of licensed Professional Engineers in British Columbia, at the rate of 80 hours per year, and provincial regulatory bodies such as EGBC provide guidelines for their members' CPD requirements (EGBC, 2018).

A pedagogical challenge for engineering programs, adhering to the accreditation criteria, is to ensure the program is also providing education that encourages a conscious development of self-knowledge and the ability to self-regulate as a professional, and thus the need to establish an understanding of one's own professional identity. Since engineering ethics is part of thinking like an engineer, the conscious development of a student's professional identity will include considering the development of the students' character, ethical reasoning ability and awareness of ethical standards and their application. While there are many ideas on professional identity formation, James Gee's four ways of viewing identity give a clearer idea of how identity relates to ethics (Gee, 2000). First, Gee notes, we all have a *Nature-identity*, (a state) developed from forces in nature – like being tall, or Caucasian. Second is *Institutional-identity* (a position) approved by authorities within institutions such as universities issuing degrees. Third is a

*Discourse-identity* (an individual trait) recognized in the discourse or dialogue of rational individuals. In other words, how professionals or others talk about themselves. Finally, Gee mentions an *Affinity-identity* (which are experiences) shared in the practice of affinity groups – or the professional practice of being an Engineer for example. This lens offered by Gee demonstrates how the professional identity formation of an engineer will have a direct influence on the professional's knowledge of self and on his or her own work ethic. This aspect of ethics learning connects to Aoki's curriculum-as-lived experience, and will offer learning that curriculum-as-plan may not (Aoki, Pinar, & Irwin, 2004).

There are several ways to include ethics education more robustly/fully in the engineering undergraduate curriculum. Barry & Herkert (2014) see "…the primary methods of incorporating ethics within curricula" as including "required courses within the discipline, required courses outside the discipline, ethics across the curriculum, and linking ethics with societal implications of technology" (Barry & Herkert, 2014, p. 676). The UVic B.Eng program uses a required course within the discipline approach with two first year courses listed for accreditation, and a linking of ethics with societal applications in *ENGR297: Technology and Society*. *ENGR130: Introduction to Professional Practice* is built and taught by professional staff from the Engineering Co-operative Education Department, and *ENGR297: Technology and Society*, by Faculty members from the Philosophy department. ENGR130 uses part of one class to mention the EGBC Code of Ethics, and ENGR297 does indeed consider the societal implications of technology, as the title implies.

## Engineering Ethics in Practice and Education: A Warrant for this Research

Engineers today must be prepared to work with technology that is constantly changing and evolving with scientific discoveries, and the influence of business and commerce on the speed at which new technologies are monetarized (often with little consideration of the impact on human well-being). New financially viable technologies continue to appear which bring with them new ethical issues; for example:

> …smart phones (with built in global positioning systems), microprocessors embedded in everyday objects, smart cards, radiofrequency identification tags and implants, and face recognition technology, all potentially interconnected in faster and faster wireless broadband networks. Technical possibilities such as these pose daunting ethical challenges, especially in protecting personal privacy in a system designed to know who you are, where you are, and all your personal preferences (Barry & Herkert, 2014, p. 686).

A fundamental question facing engineering ethicists is whether these emergent technologies have unique characteristics that differentiate them from preceding technologies. The 2018 World Economic Forum reports that new and emerging technologies will drive economic growth and see a shift in the type of roles available in the workforce (World Economic Forum, 2018, pp. 7-10). Arkin discusses the challenges facing software engineers who will program robots and need to consider their ethical decision making processes (Arkin, 2009). Moor also sees a proactive approach to ethics being needed with the increasing pace of technological advances (Moor, 2005). The consensus among these scholars seems to be that issues such as complexity, embeddedness, and the accelerating pace of development, are converging with one another in both processes and products, with the need for raised awareness of ethical

issues and even proactive ethics of some sort (Moor, 2005). This is often evident in the work being undertaken by biomedical engineering students at UVic, for example, who work at the intersection of several fields in projects of a Biomedical Microelectromechanical systems (BioMEMS) nature. These include examples such as low voltage brain implants that help sufferers of Parkinson's disease to overcome their tremors, and pacemakers that assist in heart health. With the complexity and accelerating pace of technological development giving us artificial intelligence and machine learning, and with the ability to process vast amounts of data at speeds never before achieved, "emerging technologies require more than ethics as usual, including ethical thinking that is better informed, more proactive, and characterized by more and better interdisciplinary collaboration among scientists, engineers, ethicists, and others" (Moor, 2005, p. 112). This technology brings with it the issue of moral agency, and raises questions such as when does the machine (making autonomous decisions) become an artificial moral agent? This confluence of technology and ethics is where the ideas of preventative ethics or anticipatory ethics have been discussed in reply to a machine ethic, necessary for the converging complexity and embeddedness of emerging technologies (Johnson, 2011). These proactive approaches to ethics are most significant in computer and software engineering, and while the fundamental moral reasoning abilities required of engineers has not changed very much over the past decades; "what has changed, in relatively recent times, is the potential modern engineers have for broader and more significant impacts on society…locally, nationally, and globally" (Barry & Herkert, 2014, p. 676) . Another consideration seen in recent literature is the integration of risk management considerations in engineering ethics education. Risk management knowledge and skills are imperative to mitigating the safety responsibilities inherent in engineering

professional work. “A more engaged relationship between risk management and ethics has…to be integrated in engineering education if we wish to promote the necessary change within the profession toward more socially and environmentally responsible practices” (Guntzburger, Pauchant, & Tanguy, 2017, p. 339). Pritchard and Englehardt (2015) address educational approaches to teaching ethics in engineering in broader brush strokes, saying that “…engineering ethics is a kind of *practical* ethics, this reminds us that the primary aim should be to help our students obtain a better understanding of how they might constructively address the sorts of ethical problems that arise in engineering” (Pritchard & Englehardt, 2015, p. 118). This practical rather than theoretical approach to teaching ethics in engineering education has the potential to engage the learner with the application of ethical standards rather than confusing the learner with the exposition of ethical theories from philosophy. Drake, Griffin, Kirkman, and Swann (2005) compare a full semester ethics course with an engineering course that includes ethics modules, and concluded that in order to“…improve a student’s moral reasoning and sensitivity to ethical issues, engineering ethics must be integrative, delivered at multiple points in the curriculum, and incorporate specific discipline content” (Drake, Griffin, Kirkman, & Swann, 2005, p. 229).

## Conclusion

This review of the literature began with an indication of some of the theorists who contributed to the development of my own understanding of education, curriculum, and ethics. While keeping in mind that a focus of this study is curricular improvement, reviewing literature on the professional development of engineers, engineering education in general, and considerations of engineering ethics education, provided a survey of engineering ethics and curriculum. An understanding of the Canadian Engineering

accreditation requirements and of the current UVic B.Eng curriculum helped to locate this research in the context of how undergraduate engineering ethics curriculum effectively prepared the participant professional engineers for the ethical challenges arising in their professional practice. This research is also motivated by the need to raise awareness among young engineers to the level of impact their technical work has on the social world around them, and equip them to make effective and timely ethical decisions in their professional work. By considering which learning occasions in the UVic B.Eng program provide this learning, and enquiring as to their fluency and professional application of this competency, this research endeavors to find opportunities for contribution to curricular improvement. This study contributes to the literature in the field through considerations of how the experiences of the participants can contribute to improving the type of curriculum and pedagogy required in effectively teaching ethics in engineering education.

"The application of engineering knowledge will hold little value if not performed in an ethical manner. Accordingly, the performance of research related to the instruction, retention, and application of engineering ethics is a field that deserves and requires continued funding, sustained exploration, and persistent dissemination of findings" (Barry & Herkert, 2014, p. 687). I share this sentiment and believe that the assessments of the young professional engineer participants in this study, based on their learning and professional experiences, will help to better plan and design engineering ethics and equity curriculum. In the next chapter I will discuss the methodology behind my research, and the methods via which I conducted the study, with considerations of how a case study of these participants' experience of learning ethics at UVic Engineering will inform ideas

and innovations for improving the design and delivery of engineering ethics and equity education in Engineering programs.

# CHAPTER 3: METHODOLOGY AND METHODS

This chapter consists of two sections. In the first section: methodological approach, I consider the philosophical and methodological underpinnings of the study. This includes an exploration of interpretive and constructivist paradigms to establish ontological and epistemological grounds for this research. In the second section: research design and methods, I explain the process from participant recruitment and biographies through interviews and data analysis to interpretation and write-up.

## Methodological Approach

The methodological underpinnings of this study are grounded in a social constructivist perspective, which sees knowledge as co-created by the different collaborators interacting through participation in settings such as classrooms, laboratories, and workplaces. This brings together the ontological (worldview) and epistemological (ways of knowing) significance of the researcher's and the participants' collaboration in understanding professional engineering education through these shared lived experiences. Social constructivism is a sociological theory of knowledge according to which human development is socially situated and knowledge is constructed through interaction with others (Davis, Sumara, & Luce-Kapler, 2008). By this view we see that individuals seek coherence with others and their understanding of the world in which they live and work. "[They] develop subjective meanings of their experiences... meanings that are varied and multiple, leading the researcher to look for the complexity of views rather than narrowing meanings into a few categories and ideas" (Creswell & Creswell, 2013, p. 8). In this research, I chose to use case study as a lens through which to analyze the learning opportunities within the curriculum for learning ethics and equity

in the UVic Engineering Program. This will be informed by hearing the viewpoints of recent participants in the program.

### Case study

A case study is considered a detailed examination of a specific example, then facilitating the use of that examination to look at a broader understanding of other interpretations of that example (Abercombie, Hill, & Turner, 1984). This study is a descriptive interpretive case study examining the social and professional learning experiences of a set of recent graduates from the undergraduate engineering programs at UVic. Taking a constructivist perspective allows me to view the participants and myself, the researcher, as co-creating an understanding of the experience of learning ethics while studying engineering. The selected participants represent a cross section of recent graduates from the UVic B.Eng program, who all experienced their education in unique and subjective ways. This means that each participant will discuss their experiences differently and this study will determine common issues that are raised through the participants' interviews.

### Interviews

The use of semi-structured interviews allows the researcher to direct the focus but also allows the participants to contribute unsolicited information as it arises in the interviews. The interviews involve a conversation with the participants about their own developmental experiences as engineers, guided by questions, (see Appendix 2) which address concepts such as professional development and identity formation to hear and capture their experiences. This case study considers a polyvocal perspective within the research by hearing the voices of the different participants (Sparks, 2002). This intersubjective understanding of the experiences of these engineers, (that is, the shared

and common subjective experiences of the participants in the study), along with the contextualization offered in the introduction and literature review, offers insight into the experiences of learners in the program, and has the potential to identify areas of the current curriculum with scope for addressing issues of ethics and equity learning by Engineering students.

This methodological approach produced data for the case study constituted by a common response to the research question of how these recent graduates discuss their learning of ethics and equity in their Engineering program. By hearing and analyzing the perspectives of the participants this study uses these views to develop an understanding of the capacity and perceived efficacy of Engineering programs' teaching of ethics and equity to developing professional engineers.

## Research Design and Methods

This descriptive interpretive case study looks at how the participant Engineers discuss the ethics and equity related learning occasions during their engineering undergraduate education in the context of how they contribute toward professional development as an engineer.

The scope of this study, while limited to the subjective experiences of the participants, is in the context of the Canadian Engineering Accreditation Board (CEAB) requirements for undergraduate engineering programs, and specifically located within the UVic Engineering expression of these requirements.

Moral and ethical decision-making involves putting into action the moral beliefs we hold and is applied in negotiating equitable human relations. Professionals such as engineers hold more social responsibility than they realize when it comes to the influence of technology that has become so integral to the lives of so many. This puts practicing

professional engineers in a position of privilege and responsibility by virtue of designing, building and maintaining the technology that society relies on to keep social, economic, and political systems working. This is acknowledged by engineering regulatory bodies and often referred to as the *social responsibility of the engineer*.

By telling our stories we define our world and make meaning of our lives. My professional work as a career educator with engineering students has afforded me the privilege of hearing thousands of stories over the past ten years from young engineers with a wide variety of backgrounds and interests in a broad range of technologies and industries. The way these young professionals approach their transition from university to work is as unique as they are, and this research integrates their stories and my own, elucidating the intersubjective interpretations of the developmental process involved in becoming a professional engineer.

One challenge I faced in undertaking this research is the different epistemological viewpoints commonly expressed by engineering researchers and education researchers, with engineering research being predominantly quantitative and educational research more commonly qualitative or mixed methods. In this research, I consider engineering education, however it is the professional, social, and moral aspects of engineering education that is focused on, using a more qualitative approach to the study informed by the lived experience of the participants (Creswell & Creswell, 2013).

**Data and contextual sources**

While the primary data used is in the form of transcriptions from the interviews with the participants, these are analyzed in the context of, and with consideration of contextual data from several other sources, such as the academic and commercial sources outlined in chapter two's literature review. This range of academic, industry, and

government resources provided the context for the research – firstly in the broader sense of the professional labour market for engineers in Canada, and then from the perspective of engineering education in Canada. The contextual sources provided me with a deeper understanding of the workplace and labour market challenges that face young engineers in the 21st century. By having a good understanding of the professional context in which these young engineers will be making ethical decisions, I believe that my perspective takes into account the broader background in which they conduct their professional practice.

**Primary data collection, researcher bias, and participant biographies**

Interviews were conducted in person, capturing the experiences and perspectives with the narratives used by the subjects in discussing their personal experiences through their education. The past decade of experience facilitating workshops and working individually with engineering students allowed me to effectively expand on the central interview questions with probing questions that helped the participants to recall and articulate their experiences in a comprehensive manner, while keeping myself as the researcher cognizant of my own bias. It was important for me as the researcher to set aside, or bracket my own understanding of what ethics and equity meant, to hear the participants' interpretations without disclosing or explaining what I understand by ethics and equity. My own understanding of ethics is informed by my experience of undertaking a philosophy degree, along with a decade of professional work in the engineering field before coming to work as a career practitioner with engineers. Creswell and Miller (2000) talk of an approach they refer to as researcher reflexivity, involving an intentional suspension of biases (my preconceived ideas of ethics and equity) and a focus on the participants' understanding of the concepts (Creswell & Miller, 2000). With a focus of

this study being ethics and equity learning, my initial perspective as the researcher was to look at how the learning was integrated and applied to professional work after graduation. The participants' raising of issues around academic integrity in the program however shifted my focus and helped me to realize that examples of ethical issues within the program are also germane to the learning of ethics and equity. By maintaining an awareness of my perspective as a career development practitioner with engineers – realizing that my opinions and even my questions were somewhat motivated by my experiences over the past decade – I listened for these engineers' own recollections and understandings of what ethics and equity meant to them. For this reason, I approached the interviews with a focus on the participants' perception of ethics and on how their own experiences created the data related to their ethical learning in their Engineering Program. An example of how I went about this is that I intentionally asked participants how they define themselves as an engineer, before asking them what ethics and equity mean to them personally. Taking this approach, I believe allowed the participants to ground their understanding in the idea of self as professional making autonomous ethical decisions, and not only as a reaction to my questioning, or a theoretical understanding of the terms.

By limiting the sampling of participants to EITs who were recent graduates of undergraduate engineering programs at UVic, I was working with narratives referring to experiences of the same university and faculty for all participants. Given that the UVic Engineering program also includes a mandatory cooperative education requirement, all these recent graduates had at least 16 months of workplace experience before graduation. This context affords a level of credibility to the stories told and recorded because all participants were discussing experiences of the same program and requirements. These shared histories also ensured that common participant experiences (of learning ethics and

equity in the B.Eng program at UVic) were transferrable and that the intersubjective meaning made through these narratives are confirmable in the context of this study.

Participants of this study are alumni of the UVic Engineering program who were available on the LinkedIn professional network. To avoid conflicts with my role as a career educator, who also provides service to alumni, all participants were employed as engineers and working in the Victoria BC area. This ensured that there was no misunderstanding that their participation in this study might curry favour in assisting them with a concurrent work search process. Alumni who fit the criteria (recent graduates of the Engineering program who were working in the field locally) were sent an invitation to participate, which included an overview of the research and the interview questions to be used (see Appendix 1). Five people responded to my invitation, as described below:

**Sandy**– works as a mechanical engineer with the marine division of a large multinational engineering company who specialize in high-pressure steel tanks and vessels such as submarines.

**Jim**– works as a mechanical engineer and manager for a contracting company, designing and overseeing the installation of industrial refrigeration systems in a diverse range of applications on Vancouver Island.

**Jake**– studied electrical engineering, however he works for a tech start-up company that uses social media data to locate individuals in the physical world – a service often required by law enforcement agencies. His work involves software skills and professional negotiation skills.

**Kevin**– studied mechanical engineering and works at a number of different jobs including software engineering for a tech start-up, and sales of mechanical equipment for industrial applications.

**Samantha** – studied software engineering and is employed by a bioscience/genetics software company. Samantha previously had a career in the performing arts, coming to engineering as a mature student.

## Coding process

The transcriptions of the sound recordings from the interviews were analyzed using the open source qualitative data analysis software Qualyzer (similar to NVivo), with the researcher reading through all transcripts numerous times in order to identify the areas of focus from the data. Related pieces of data were labelled as such and the researcher used Qualyzer to collate the categorized findings into collections of data with a common focus. Before analyzing and coding the data the researcher developed an understanding of open coding, axial coding and selective coding as methodological tools via which to approach the data (Mills, Durepos, & Wiebe, 2010). The coding was done with the research questions in mind, and beginning with an open coding approach of labelling sections of the data into groups of related comments that emerged as areas of common focus by the participants throughout the interviews and discussions with the researcher. Then, using an axial coding approach, these related comments were categorized with consideration of how they addressed the participants' understanding of ethics and equity from their learning experiences, and how this was exemplified in professional practice examples of ethical application. The categories that emerged centered on the participants' own level of understanding of the terms ethics and equity; how the participants' recalled learning ethics and equity in the engineering program; and

an example of how they applied this learning in a professional setting. These three areas are considered important to this study because the participants' understanding of the terms offers an insight into their learning, and their recollection of learning occasions locate that learning in their course work and the engineering program. The third category of applying this learning in a professional capacity helps to show how their learning has been integrated and can be applied in their professional work.

## Conclusion

This research, then, focuses specifically on Engineers Canada's Graduate Attribute number 10 – Ethics and Equity, as I described in the more detailed review of the CEAB curriculum requirements included in Chapter 2. By asking recent graduates from the UVic B.Eng program about their experiences of learning ethics and equity, this study considers the participants' understanding of the terms ethics and equity and then explores how they have been able to apply their learning in a professional ethics example. Using a case study methodology, the participants' experiences relating to the two research questions inform all aspects of this research, and were collected and analyzed:

1. How do recent graduates describe their experience of learning ethics and equity in the UVic B.Eng. program, while making meaning of their professional work in terms of ethics and equity?
2. In relation to effectively teaching ethics and equity in the B. Eng. curriculum what can we learn from the experience and practice of recent graduates?

The research questions are framed first to hear the experiences and recollections from a group of engineers who completed the same program, and second ask how their perspectives might contribute ideas for improving the ethics and equity curriculum and

teaching at UVic Engineering. In chapter 4 the voices of the participants will help to elucidate the attitudes, understanding, and professional impact of their learning of ethics and equity in their Engineering program.

# CHAPTER 4: FINDINGS

## Introduction

The idea of *ethics* can mean something quite different for each of us. Personal ethics are directly influenced by what one sees as right or wrong. Professional ethics, on the other hand, often hinge on standards set for a specific profession (like Engineering), and the respective code of ethics that must be followed. As much as these personal and professional ethics have their own characteristics, we cannot really separate them out – our personal ethics will necessarily influence our professional ethics and vice versa.

This chapter begins with a consideration of how the participants discuss their overall experience of studying engineering and includes an analysis of the discussions with participants in the semi-structured interviews. It is important to note that research questions were framed in terms of the learners' experiences.

Participant Engineers are recent graduates from the UVic Engineering program and are currently practicing professionals in several different industries. Interviews and pursuant discussion were initiated with 10 questions, but also allowed the respondents to speak freely about their experiences and reflections of how they learned ethics and equity while undertaking their B.Eng. at UVic. My choice of questions and the order of the questions intentionally started by locating the learning in the engineering program, and locating the understanding of ethics and equity in the participants' own experiences. The interview questions are intentionally open-ended in order to elicit stories from the participants, allowing for the same set of questions to elicit the various subjective experiences of the different participants (Mills, Durepos, & Wiebe, 2010).

The 10 core research questions that were used in the interviews are listed below:

1. Tell me about your experience of studying engineering at UVic
2. How do you describe yourself when someone asks, “What kind of engineer are you”?
3. What does ethics and equity mean to you?
4. How would you define your personal/work ethic?
5. Tell me about an experience at UVic that helped you most in learning about and understanding ethics and equity, and why? (courses, student groups, co-op work terms, conversations)
6. How have these experiences contributed to your understanding of ethics and equity as a professional engineer in training?
7. Tell me (in broad terms – to maintain confidentiality) about an ethical challenge you have faced in the workplace, and how you dealt with this, and what equipped you to deal with this?
8. Tell me about your Ethics & Equity learning in any of the courses taken?
9. Tell me about your experience of studying engineering (from an Ethical perspective). What worked, what did you disagree with, what moral/fairness/equity issues (if any) did you experience?
10. Any other stories from your experience that are relevant for this area of learning for engineers?

The outline of the subsequent discussions followed these core questions, but each participant expressed a unique recollection of their experiences in their Engineering

program. Transcripts of these conversations were analyzed for relevance to the research questions and three categories emerged.

The three categories that emerged from the data were well aligned with the research questions and focus of the study: (1) *personal understanding of what ethics means;* (2) *learning ethics;* and (3) *applying ethics in the workplace.* A fourth unanticipated category that surfaced – *academic integrity* – was identified by all the participants, which raised the subject of ethical behaviour within the academic program itself.

## Participants' Overall Experiences of Studying Engineering

Interviews began with a general question about participants' experience of studying engineering at UVic. My intention was to explore their broader experience of studying engineering, then move through the interview questions with specific inquiry around their learning in ethics and equity (practiced in the workplace), both as interns and as engineers in professional practice.

Jim, a mechanical engineer working in the refrigeration industry, recalled his experience in a very positive way, saying he found his "professors very approachable, willing to help, and very interested in answering extra-curricular questions -- say about designing something on the side." This focus on design stands in contrast to Sandy's experience, which showed a more personal and developmental experience, with her saying

> *it all kind of clicked where adult life is, what socio-economic environment I want to belong into, where you know, you have like-minded people, it's just all kinda fell together, it wasn't just the education part of it, it was like a large social part of adulthood that I maybe came in touch with through co-op and having great*

*supervisors, great mentors it just kinda pieced the last, piece of the puzzle. Adulthood kinda fell into place for me.*

While Jim's overall experience of his Engineering program was recalled through his interactions with faculty members on technical issues, Sandy expressed a more holistic experience, discussing her experience as a developmental part of her life. This difference between Jim and Sandy's experiences raised my awareness to potential connections between personal, professional, and moral development, and reminded me that different foci of learners depends on social, cultural, and gender influences. Jake, who was a member of the Engineering Student Society (ESS), stated that the most interesting experiences for him "…*were all from the student society stuff, or various events like that, either competing as an engineering student across Canada or going to various conventions and conferences on behalf of UVic ESS*."

A fourth participant, Samantha, conveyed how intimidating it can be for mature students in a young cohort, and female students in a predominantly male discipline, saying, *"...it wasn't my first choice to be in a male dominant faculty, I might have felt a little uncomfortable, but I was already, like two counts against it, like I was too old, and I was also female, so you know, doesn't matter*." The "...doesn't matter..." remark provided new insight into how this female student (as a minority in engineering) dealt with the challenges. Samantha was making a change from an arts career into an applied science program, needing to focus and she chose not to allow any barriers to matter too much, and successfully approached the learning she undertook. As for anyone in a minority situation, it takes courage and tenacity to successfully participate in a course of study as one of the only 10% female students. This stands in contrast with the majority of engineering students at UVic and in general across Engineering programs – the white

English-speaking male – who (from my experience) often demonstrate little awareness of the privileges afforded them.

The fifth participant Kevin, presented a broader expression of his participation in the Engineering program, alluding to the importance of extracurricular and co-curricular activities of the student experience:

> *I enjoyed what I learned from a learning to learn standpoint, I enjoyed the exposure to a great deal of different things, different ideas, socially ethically and technically as well, and not all of that came from my engineering, it came from my related things that you would say come with an engineering degree.*

These comments from Kevin also showed a more holistic experience of the engineering program in the context of university life, including extracurricular, co-curricular, and external activities which all contributed to his developmental experience.

These preliminary comments helped me as a researcher to be mindful that even though these recent graduates attended the same school and program, their individual experiences were unique to them based on their own proclivities and attitudes towards life and learning. As educators, our focus is often on the curriculum and teaching, only receiving relevant feedback via course experience surveys. In this study, my central objective was to capture the learners' perspectives as a source for program improvement around ethics and equity learning. To this end my next two interview questions focused on the individuals' own understanding of what ethics and equity means to them personally and to their profession.

## Participants' Personal Understanding of what Ethics Means

Moral reasoning and ethical decision-making put into action the moral beliefs we hold, and are applied when negotiating with others, which is an inherent part of equitable human relations. Roncin (2013) clarifies the distinction between what he describes as philosophical ethics and applied ethics, noting that many engineering schools in Canada outsource ethics classes to the philosophy department, which results in a focus on philosophical ethics rather than applied ethics. This is also the case at UVic, with the mandatory class *Technology and Society* being taught by faculty members from the Philosophy Department. Engineers Canada's 12 graduate attributes require that graduates from an accredited program develop "...an ability to apply professional ethics, accountability, and equity" (Engineers Canada, 2016), in their professional work (EGAD, 2011). In this study, I consider ethics and equity in engineering education (in keeping with graduate attribute number 10). I noticed, however, that some participants conflated the two terms and others simply considered them the same thing or confused equity as a social term versus equity as a financial term. This led me to consider the participants' answers from the perspective of how they include consideration of the meaning of "ethics" and "equity" respectively.

Jim focussed on fairness and equality in his understanding of ethics, also considering workplace safety and saying that his

> *definition of ethics would be to do what is right and fair regardless of the monetary outcome, regardless of how it affects me or how it affects you and to look at everyone to make sure it is fair and safe for everyone involved.*

Jim is also the participant who commented that he understood equity in financial terms, demonstrating little understanding of the meaning of equity as Engineers Canada hoped,

saying that "*equity means what value does something have to you and what value is it going to have today vs tomorrow sort of thing*". This misunderstanding of what equity means in relation to Attribute 10 suggests a misinterpretation of learning "ethics and equity". Sandy, on the other hand, expressed a very clear distinction between the two, with her commenting, " I think I would define them [ethics and equity] separately". Sandy continues, saying that what

> *...ethics means to me is following the rules, like that's how I would describe ethics, and whether those rules are rules of you know, how we treat people, like being a good general person or, rules as in following the ASME code for boiler welding, or rules as in like, you know laws of society.*

Sandy, however, *establishes a clear distinction between ethics and equity* by defining equity as:

> *treating everybody equal, as if you were blind or had a blind fold on, you just hear that voice of the person talking, you blend out gender, you blend out what they look like not just race but, you know, are they pretty, are they heavy, are they really thin... it doesn't matter, it's like a blind veil and you just hear what those words are, are they you know good enough, to be doing this position.*

So, we hear Jim explaining what ethics means and taking a guess at the meaning of equity, while Sandy clearly distinguishes between ethics and equity as two independent concepts, with neither taking up the terms or concepts very deeply. Jim's approach to ethics has an economic view of what equity means. He presented the financial understanding of equity as having a financial stake in an issue rather than the social concept of fairness, showing an equivocation of the idea of equity. Although Sandy's

definition of *ethics* is like Jim's, her description of *equity* shows more of a social awareness (as intended by Engineers Canada's graduate attributes). This is an important observation, as the tendency to overlook equity from the learning in Engineering programs is also evident in the literature, where studies such as Roncin (2013) began discussing *ethics and equity* as part of the CEAB's required learning outcomes for accredited engineering programs, but ultimately omitted equity, with a focus only on ethics. This suggests an issue of focussing on what is clearly understood (like ethics) and glossing over the concepts less understood, or not valued (like equity) may be common among participants, but also appears in the literature, suggestive of a similar attitude in Engineering programs.

Engineers are applied scientists, and use math and physics as tools to apply their problem-solving skills; this involves reasoning to a conclusion that is defined in certainty with mathematical accuracy. Jake shows how this perspective impinges on his understanding of ethics when he says

> *my thing on ethics is again, always come from the engineering standpoint, what is the policy and the rules around how we disagree and how I communicate what feels good to me and how we, you know set up a system to act around what the whole team is going to feel good about.*

While Jake demonstrates a more personal view of ethics, he also refers to what *"...feels good to me...*" and "*...what the whole team is going to feel good about*", alluding to a more Humanist approach to ethics, with a consideration of feelings. Engineers as applied scientists often pride themselves on their foci on logic and mathematical certainty, yet Jake expresses an understanding of ethics that relies on feelings. This is significant insofar as it demonstrates a tendency to include feelings when thinking of ethics or right

actions. Samantha, when answering questions 3 and 4, prioritizes equity over ethics, saying

> *I think that ethics and equity, to me immediately what comes to mind is equal pay for equal value, or yeah, so shouldn't be judged on anything other than the work you do, and I think people don't really know they have prejudices.*

These observations underline the finding that most of the participants confused (or at least demonstrated only a vague understanding of the difference between) *ethics* and *equity*, indicating that these engineering graduates have a limited understanding of social justice issues and a limited awareness of the privileging and non-privileging of people in the world. Does this perhaps imply that these recently graduated engineers work in a sector where privilege is taken for granted? The difference, for example, between *equity* and *equality* is not addressed by any of the participants.

Samantha does, however, provide an interesting perspective on applied ethics in engineering by using Star Trek as a metaphor for an ideal ethical system guided by engineering principles, saying there is an

> *interesting connection between art work and engineering in that whole Star Trek thing, they upheld this (even though it was imaginary), it was this amazing world of morality and ethics, ethical behaviour, and I think to myself how can I do a blog called Treckonomics because how did they get to that point when everybody had what they needed, and contributed what they could. It sounds like communism, but it wasn't communism, right, it was this engineering utopia, existence, right, where engineers were very highly respected members of the crew,*

*and yeah, they were almost like the most important characters. There was the Doctor, the Captain and then there are Engineers.*

Popular culture often mirrors the social issues of an era, and as such Samantha's Star Trek analogy reflects my earlier concerns as to ethical decision making in a time when the pace of advancing technology will have an impact on decision-making abilities and therefore on ethics. I also hear in the analogy Samantha makes, an ontological inclination to the Profession of Engineering – as a traditional large "P" Professional rather than simply a small "p" professional as in professional behaviour, or professionalism. An *engineering utopia* would rely on logic and a search for certainty in interpersonal relationships, which is a limiting of morality and ethical behaviour to the cognitive realm, whereas we have seen with the ethics/equity distinction in Jake's comments that emotional motivators, which are subjective to the moral actor being considered, also impact ethical behaviour. Many ethical decisions involve a subjective commitment to a certain ethical perspective, and this can cause dissonance for ethical actors in the engineering profession where the idea of objectivity is valued so highly. What I mean here is that engineers and engineering students appear to prefer engaging with the technical aspects of their work (where their strengths are), and do not always realize the opportunities to think about ethics or equity.

The final respondent, Kevin, said that to be ethical "...you operate in a manner that is transparent, it allows everybody to see that you are behaving in a very ethical way, such that no-one could ever question my ethic." Here, the use of the word "ever' in this case signals an absolute, or at least dualistic, approach to ethics, something that challenges the intersubjective nature of ethical problem solving. By absolute and dualistic, I mean the idea that ethical behaviour can be explained as simply right or

wrong. This approach demonstrates that the respondent sees ethical action as resulting in unquestionable correctness. However, ethics is equivocal in nature given that a number of subjective moral actors are often involved, so looking for objectively or unequivocally right answers in ethical dilemmas is ill founded.

In summary, the participants described their differing approaches to ethics and equity, with some not really defining ethics, but rather equating morally right action with technically correct action, essentially assuming that as long as their math is correct they are doing their due diligence. This further supports my observations that engineers are predisposed toward applying mathematical and scientific standards of certainty towards moral reasoning and ethical choices, and thus supports the literature that "engineers...prefer more highly prioritized thinking" (thinking according to a plan) when it comes to ethics (Gridley, 2007, p. 178). The different perspectives on ethics and equity, expressed by participants, also support Gilligan's challenge to Kohlberg's moral development theory (Killen & Smetana, 2006). Moral development is not simply a progression through stages (as in physical development), but rather includes considerations of the individual's gender, cultural origins, context and interpersonal skills. Moral reasoning and ethical behaviour are more than just cognitive processes of aligning beliefs with actions but are reliant on the whole person – the cognitive, emotional, and social identity – that interacts with other moral actors in a world where ethical understanding is only one part of right action, in peaceably disagreeing with others yet living alongside them.

### Perceived Program Impact on Learning Ethics

A student will experience an academic program according to their unique learning style, academic ability, extra/co-curricular interests and pursuits, and will experience

learning ethics in that program in a manner that builds upon their existing views of ethics and the views expressed by their instructors. Other factors such as the culture of the university, diversity within their cohort, and current affairs will of course impact their points of view. We see this influence emerging in the answers to questions related to their experiences at UVic.

Beginning again with Jim, he makes a connection between ethics and Humanism, with his comment that he

> *...think[s] that ethics is related to humanity, and... found that ethics and humanity were treated as if they were a soft science, sort of thing, at UVic. In the sense that they were there, but they taught them because that they had to teach them...my professors would say ... oh, so and so invented this form and then they died a very horrible young death, and that would be the 20 second intro, let me get on with the class. It was more we don't care who did this, we don't care about the reasons behind it, we don't care about how this was developed, whether it was ethical or all this kind of stuff, all we care about is that it was and now we are going to apply it and so, with regards to that I would say it wasn't treated with as much respect as I think it could have been...it was more sloughed off and it was deemed not as important as the true science itself.*

Clearly, Jim's experience exemplifies the disconnect between understanding engineering theories and learning to apply those theories with an awareness of the social impact that engineers' work may have on their clients or humanity. This experience is counter to the learning outcomes prescribed by the CEAB, which indicates that graduates of Canadian engineering programs should understand how to apply ethics, equity, and inclusivity in their work (EGAD, 2011). Approaching the teaching of ethics in the same way as

teaching science, educators tend to focus on foundational theories and factual content rather than on the process. Jim said "*I learned most about ethics [when] we had debates, and I think it is the best way to learn about ethics, because you learn that there are different opinions than yours and that there are different ways of looking at life*", while also expressing the importance of experiential learning in applying the theories learned in the classroom, saying

> *I think it's hard to make someone actually understand something until they experience it for themselves, until they've actually had to face the ethical conundrum as opposed to talk about something in class abstractly, so I'd say I learned more from co-op work experience than actual classroom experience.*

This response demonstrates that the learner – who has since gained some professional experience – realized that applying ethics in their professional life has been more effective in teaching them the meaning of ethical concepts than learning these in an academic course. This speaks to my research question regarding how ethics learning was experienced at UVic, and raises the topic of the Engineering program's responsibility to explicitly address ethics learning issues, rather than hoping graduates will gain insight once working as a professional.

In her answer to the questions regarding the program impact on how she learned ethics, Sandy helped me to appreciate how it feels to be a young female in first year of an engineering program. She explained that,

> *...we would build a spaghetti tower, but the whole idea was getting the team dynamic going more and it was in those places that I learned more ethics and equity because I noticed immediately that some people based on how strong their*

> *personality was, sometimes their gender,… their opinions were been like really put back by certain group members, and that's the first time, that I ever felt like somebody had put me down, there was one instance where, there was one way to fix the tower and it was really obvious and I proposed it several times, and one guy totally ignored me, so then I just took the spaghetti out of his hand and fixed it, brought the tower... and everybody was like, wow, how come we didn't think of that. And I was like ...chuckle... yeah, so that's one of the experiences where I first experienced maybe un-equality just because I was the only girl in the whole class also. Which I find empowering, that to me is a good thing. But I think that, it was like those labs just right in first year where the most learning. Everybody, once we got going into 2nd year, I had no issues, like everybody really kind of progressively grew into equality and ethics. Like people grew with it, and I think co-op had a lot to do with it, but I think the first instances where I saw maybe unethical unequal things going on was more in first year, when more people were still kinda young.*

The strength of character required to overcome the discrimination experienced by female engineers during their educational experience is clearly expressed here by Sandy. Based on my decade of working in an engineering program, I see this type of experience as perhaps not recognized by educational administrators from a curricular design perspective. I see a connection here to the conflation of ethics and equity – both in the literature, and in the responses from the research participants, pointing to a need in the program for a clear definition of, and differentiation between ethics and equity. Even though Engineers Canada's attribute number 10 combines ethics and equity, the male participants as well as accreditation professionals appear to commonly confuse the two,

detailing ethics in terms of professional behavior, and ignoring or simply paying lip service to concerns of equity. This conflation seems to bury equity learning under the description of ethics, apparently lessening any emphasis on what equity means and how it is learned.

Questions of gender arose once more when Jake spoke of his experience as a member of the Engineering Student Society (ESS). He described how in 2011 the engineering students accompanied the nursing students on a pub crawl/ social. During this event, some of the engineering students were reportedly singing sexist and unsavory songs on the bus – asked by some nursing students to refrain from this behavior – these young men doubled down and sang even louder. Without elaborating further, I will say that the nursing students lodged a formal complaint and faculty administration became involved. As an educator in the faculty I partnered with staff from the Equity and Human Rights Office to build and facilitate "sensitization workshops", which did not sit well with students because they were mandated to attend. Unaware of their privileged position, these young (mostly white) men saw these workshops as punishment for their inappropriate behavior rather than as an opportunity to learn something and shift their perspectives. Jake's comments talk about how his role in the Society at the time, impacted his learning of ethics and equity in the program

> *...[Engineering students] came under a fire for that, and the issues around that were basically sexualized violence and people feeling offended and appropriate action taken because of it, and then from that point of view, we had to decide which would be the best course of action so that everyone felt better about the situation and felt like appropriate action was taken. Two ESS members were very much involved in the incident... they were named within the complaint letters and*

> *everything else so balancing their best interests, we needed to support them, against the ones in the external organization who was the offended party... and trying to balance those issues with the faculty issues and making sure that we did it in a way that was right. Many of the engineers were like, oh well they should just .... (I don't agree with this sentiment), grow up and just let it go and you know lighten up, and so redirecting that into a more understanding mentality was an interesting challenge. I guess balancing those things, in a way that everyone kind of understood was probably my biggest challenge at UVic, and most interesting one.*

This was an interesting experience of learning around issues of gender and sexualized violence indeed. In his Society role, Jake was faced with offended parties and fellow ESS members who needed to understand what they had done and were mandated to attend "sensitization" workshops. From my experience facilitating these workshops, I saw the focus of these young men was to assess what they had done right or wrong according to rules, and they were unaware of the issue of inequality and the lack of respect they had shown for the mostly female group of nursing students.

While Kevin also included commentary on gender-based discrimination within the program, I end this section with this poignant example from Jake and the impact it had on the program and the university. The university just recently introduced policies and services to counter sexualized violence of this kind within the school, and the administration in Engineering continues to shift the orientation events and program structure in ways that reduce or eliminate the opportunities for this kind of unacceptable behaviour. An example of this is how the Engineering faculty has prohibited frosh week, which historically reinforced the male dominant drinking culture in engineering. While

these steps take a reactive approach to addressing the issues of gendered harassment and sexualized violence, they have also driven the dialogue underground, with participants mentioning that students now take these activities off campus. This illustrates how addressing the challenging questions around equity in an engineering program will require more than simply implementing more restrictive rules. The stories from the research participants help to realize that real dialogue is required for developing an understanding that leads to empathetic collaborative change, rather than simple control by authority.

## Applying Ethics in the Workplace

Learning about ethics and equity in the classroom and debating ethical dilemmas are just the beginning of applied ethics for professionals in today's fast paced and technology rich world, be they engineers, teachers, or accountants. As the speed of designing, making and using technology increases, so does the challenge to make adequate ethical decisions more rapidly. We see a recent example of this in how Facebook's platform facilitated election manipulation, and this has only become a publicly known issue some 14 years after the technology was first available. The increased complexity in technical business dealings (in our time of hyper-capitalism) also means that ethical dilemmas are more commonplace and more complex in the work lives of these young engineers. This means that they need to make more ethical decisions in a shorter period, and are doing this with a bias toward certainty, and with little practice gained from their professional program. In order to better understand the kind of ethical issues young professionals are dealing with, I asked the participants to tell me about an ethical issue in the workplace.

Jim's work in the refrigeration industry is local to the province and involves working to standards outlined in building and safety codes that are delineated by regulatory branches of local and provincial government. Cutting corners when it comes to code compliance can save contractors a lot of money, and Jim makes an excellent connection between the bending of rules and legality when he expresses that

> *... we deal with ethics, every day. I make decisions all the time, regarding whether I am going to build in a bigger safety factor, can I install that, is that okay. One of the biggest things that I do at work is code-compliance so, I read codes, but codes can be interpreted in different ways, okay, and so I can slide this in or I can change that, and I am meeting the letter of the law but I am not meeting the intent of the law. I think that is very easy to design around because legally then I am not ethically bound but my client is happy because they spent less money and they got around a whole bunch of compliance guidelines. And it's very tempting to do this because your clients love you for it.*

Jim uses the phrase “letter of the law versus the intent of the law” – here exposing how ambiguity can be the mechanism so commonly used for skirting regulations while avoiding liability. I mention this because I believe that in teaching young engineers better interpersonal and communication skills, which assist in navigating interpersonal ambiguity, we are also teaching them how to navigate the ambiguous ethical choices they face in the professional workplace. These are not skills that are gained via mathematical algorithmic development but are important, not just for financial reasons, but also for bias awareness and ethical decision-making.

Sandy related how she deals with the potential dissonance faced in a workplace where the young worker does not have much power, saying *"I also had one of these*

*experiences where somebody is very unethical generally in the workplace, but they are so amazing at their job, that you kind of have to close your eyes sometimes*". Learning how to turn a blind eye to ethical issues so early in their careers can set young professionals up as vulnerable to liability, and of course can result in them learning that bending the rules for a few dollars more is worthwhile. In promoting ethical behaviour, one challenge is the lack of incentives to act ethically when doing the opposite is often more profitable.

With social media making our world a more connected place and allowing us to reach so many more people, it is common for most of us to use platforms such as Twitter or Facebook in our daily lives. Jake works for a company whose software product helps law enforcement agencies use social media as a method for locating the users geographically. As one might imagine, this has far-reaching implications insofar as the reach and power this software gives its users. Jake explained how his team is challenged when countries such as Turkey or Uzbekistan approach them to purchase their product, and while they have guidelines from NATO and the United Nations, they must ultimately decide whether to sell the software or not. While this is an area where Jake's team must use standards such as those set out by NATO to make difficult ethical decisions, he also commented on how there are positive impacts of their product, such as the time when "here in Victoria, as a result of our software, we saved a person's life and we had a public recognition from Victoria Police department". This shows us how a product can be good or bad depending on how it is being used. This company did sell their software to Turkey, but not to Uzbekistan, based on UN guidelines and discussion within the team. This example gives a good sense of the broad and impactful ethical decisions that engineers make every day in the workplace.

Samantha also works for a software company, but her company develops life science software that assists scientists in genomics work, an area that is becoming more critical in terms of ethical decisions because of gene splicing and genetic modification fears. This is an example of how engineers work in big teams building complex systems such as software, which can be considered as quite innocuous, but these systems can have a powerful impact on things as important to humanity such as genetic engineering. This helps to comprehend why an applied understanding of ethics (not only theoretical), and the development of moral reasoning skills are so important to engineers who are designing the technology that directly impacts our wellbeing and survival as humans.

The final participant, Kevin, gave me an example of a supposedly unintentional racist slur that he witnessed when working for a local engineering procurement and construction management (EPCM) company. Racism can be construed as a political issue, but when we are considering ethics and equity in engineering education, racial discrimination certainly falls under the domain of ethics and equity. Kevin commented that

> *I was sitting in a meeting at an EPCM firm, the engineering manager made a racist remark against I think Pakistani people or something, you know, just like very wrong and it was obvious it was wrong, and the person I'm sitting with is black -- and he's just sitting there, and he just bit his tongue. And, I was so angry, I just looked at the engineering manager, and I said that's not appropriate, I don't want to hear that stuff ... I packed my books up and left the meeting which he'd called… and he's like --- grumble. Later, he tried to back pedal a little bit, and you know, basically put the blame on me and said, by you doing that you made me look like a racist, - I looked at him and said, I made you look like a racist, you're*

> *the one who said the comment, in front of someone of a different race, and he just couldn't get that. From then on, we always had stress because I'm perfectly willing to say my opinion, if you want to fire me, then so be it.*

Speaking out about unethical behavior in the workplace can be risky and voicing one's own moral standpoint can also have negative impacts on future career prospects. Kevin no longer works for this company.

In discussing the application of ethics in the workplace most participants expressed the tension between doing what is right or doing what generates the most profit. While there is nothing necessarily wrong with making a profit, it is when the profit is prioritized to the detriment of humans doing the work, safety, environment, etc., that it becomes an ethical consideration. Engineers are taught to optimize resources and design systems that are efficient and use the least possible amount of those resources. So, when seeking efficiencies in systems such as engineering undergraduate programs, maintaining the status quo, in order to maintain control over the many innovative young learners, might easily blind educators to the individual subjective personal and professional development trajectories or careers that are emerging. While faculty wide regulations are a critical part of designing, and providing educational programming, the willingness and ability to evaluate each case as a potential exception to the rule is imperative, given the subjective nature of individual cognitive development as well as moral perspectives. The way the participants experienced their education at UVic does not explicitly help them to understand the power they hold, be it by the privilege of being a male, or because they have problem solving skills that help them navigate codes and regulations in an economically advantageous manner. This lack of self-knowledge

further entrenches the blind acceptance of one's own privilege, thus reducing the ability to appreciate the level of social responsibility carried by engineers. The kind of examples or role models UVic provides for applying ethics is demonstrated by the lenient approach to dealing with issues of cheating, (mentioned by two participants). What is at stake here is the integrity of the university and the integrity of the Engineering Profession. Given the ever-increasing number of students entering engineering programs, and the complex bureaucratic processes required in dealing with instances of academic dishonesty, it's no wonder these issues are often glossed over. In the corporate world, it is a matter of profit taking precedence over ethical behavior, resulting in an approach where professionals will prioritize profit over ethics so long as they do not incur legal liability. When professionals learn at such an early stage to turn a blind eye to poor ethics for the sake of technical mastery or profit, this is a clear impetus for asking where the gaps in the current program and curriculum are. The CEAB calls for continual improvement and curricular reform that ensures that accreditation criteria remain responsive to the needs of the Canadian engineering profession (Engineers Canada, 2017). The issue of academic integrity will be discussed in more detail in the next section.

## Academic Integrity

The fourth area that arose from the participants' insights was the issue of academic honesty, plagiarism, and cheating in engineering education, with all participants raising the issue during the conversation. Jim explained that for him certain types of cheating were effective time-management strategies in a program so packed full of technical courses that complementary elective courses are limited to one or two.

> *I mean I've seen cheating galore -- it happens all the time. At every university, it happens but that's more of a... almost a student survival mode sort of thing,*

> *because they don't have time to do the things that they are required to do. And maybe that is something to look at from a systemic point of view. If you ask your students, who are already working 12-14 hours a day and they have to copy their friend's homework to get it done on time, I think it is good because it teaches them time management because if something is worth 1% consider not doing it. It's just not worth doing. I think that's important, but at the same time too, if you load it so full that they have to bend the rules to succeed then that is something worth thinking about.*

So, cheating is justified here as a method for coping with the busy course load placed on the students by the program requirements. This attitude may well be a symptom of a program so packed full of technical courses that the opportunity for elective courses is very limited. This might be an area of focus for the continuous refining of curriculum recommended by the CEAB and could potentially benefit from a longer course of study than currently required. Alternatively, a balancing of technical courses with professional skill development courses or content would be useful. Jim continued to divulge that a certain level of cheating seems to be the accepted norm in the UVic Engineering program, saying,

> *I would never like cheat on a test or do something like that but if I couldn't finish one homework question, I may just copy it from a friend. And that was something that in the engineering department, and in those labs, is something that is not deemed as cheating, that is just deemed as good time management (the norm), yeah, so maybe to address that and things professors ... can do, like issuing new questions for every year, but that is extremely hard to do, and to be honest unfair*

*on the students too, because of how much extra time it takes to do it, because they are probably not actually learning the ideas as well.*

My own academic background has included study in engineering and in philosophy, psychology, and education, and through this diverse experience I observed that at the foundational level, cheating in a numeracy-oriented area of study like math, science and engineering is more practicable than in (literacy-oriented) education, social sciences or humanities where one must have an opinion of one's own, and express these perspectives using natural language. Remembering formulas and applying them can result in the use of exam answer keys, allowing students to pass an exam without necessarily understanding the material completely. By having to integrate the facts into informed opinions students are required to demonstrate a level of understanding rather than simply factual recollection. This raises the fundamental pedagogic concern of whether students are learning versus mastering the art of succeeding at courses. New businesses have grown out of the online demand for help from students. Classifieds websites regularly post lists of editing and writing help advertisements, and others offer students access to answer keys for exams in exchange for their own submission of similar materials. As educators and curricular designers, we are faced with a constant concern for education accreditation standards, continual program improvement and the efficacy of educational programs in educating capable professionals.

Sandy spoke about ethics learning at UVic in terms of the role models that faculty and staff play in the students' development and suggested that by taking the trouble to hold students accountable for cheating, Faculty are maintaining a high standard in the B.Eng program.

> *I think the way to teach ethics is by example, and I think that's one place... I don't want to draw on the negatives at UVic because as I said, my experience here was overall highly positive, like if I should rate my experience for the undergraduate program, I mean it probably shaved 5 years off my life, I'm not going to lie, … because the material was challenging, you know, but it's just, it's like … lead by example, when I see a teacher turning a blind eye on an academic discrepancy that is obvious to several students in the class, yeah, and it really undermines our program and profession.*

The administrative process involved in holding cheaters accountable can be time consuming, motivating a glossing over of minor offences, and cultural diversity can play a part, with norms around cheating differing in diverse groups. Staff and faculty can be hesitant to accuse somebody of cheating or being dishonest when that person is struggling with their English communication or does not clearly understand the required standards.

During his time at UVic Jake's experience was that there are students who want to earn the ability to be an engineer, but are not beyond cheating to do so, saying that *"…cheating was pretty rampant, whether it's on assignments or tests or whatever, I think that it's pretty standard in an academic environment. People who get in don't necessarily want to do the work*".

This was stated in a matter of fact manner, implying that it's not something that raised much concern. Jake's comments here relay a credentialism approach commonly seen in a post-secondary undergraduate environment. The degree or diploma is seen as an entrance permit for getting into the profession – rather than as the development of the knowledge, skills and attributes required to work in that profession. This observation

aligns with the evidence presented by Smith et al in (2016) their paper *A Literature Review on the Culture of Cheating in Undergraduate Engineering Programs,* in which the widespread nature of this problem is discussed (Smith, Bens, Wagner, & Maw, 2016). In the first six months of 2018 there were several news reports discussing cheating at universities, and how this is becoming more of a challenge. Jim's comments expressed the motivation for cheating as time management, whereas Samantha gave an example of how one student, being charitable, resulted in two students being caught cheating and punished, telling me that

> *a friend of mine was so kind, helping somebody who was in distress, and was not able to complete her assignment and was having a hard time understanding the principles, and she was really busy, so she did not have much time, she just gave her work to this person and said, well, this is my solution, you know, to give you a heads-up and give you some ideas maybe to go off and that person just signed their name to it and handed it in. So, there was this, and she wouldn't admit that she did that, so they were both called in for cheating. One, they knew that one of them did the original work, and the other one cheated, so they both got punished for it.*

In this case the punishment was that they both received a failing grade on the assignment. This is significant given that these two students faced consequences for their actions and will therefore be less inclined to repeat this behavior. No matter the motivation it seems that cheating is commonplace in today's universities according to these participants.

Kevin's comments related to a first-year engineering student's experience of the party atmosphere that became a motivation to cheat because of a lack of time again.

> *Coming into engineering the first thing they do is give you a pitcher of beer and show you how to tap a keg, right... it's crazy, so my grades steadily went down, and so I resorted to what we called, blasting... you go blast someone else's assignment, you know the night before you scribble it down. There was also, in terms of ethics, the golden disc... do you know what this is...so the golden disc is now in the cloud is a shifting set of data that exists on the cloud. Assignments and exams from the years gone by... experiments, all the exams, all the assignments, all the things you want to see what was done last year. I'm sure the profs know about it -- and it's just unbelievably complete, such that students are now like yeah, you know I can just do that all the time.*

This discussion of academic integrity included jargon like *blasting* and the *golden disc*, giving the sense that this is something that is commonplace for students in academic programs, and prompting me to look into websites such as http://CourseHero.com, where students are given credits for loading test keys from their classes in return for access to other answer keys. Students know that their study at university and their work experiences are adding potential value to their lives which they can leverage after graduation by attaining meaningful and rewarding employment. But, the measure of success at university remains grades, and students will go to all sorts of lengths to gain the highest grades.

## Conclusion

In this chapter the voices of the participants are heard explaining their contributions to the categories that emerged from the data, which were well aligned with the research questions and focus of the study. These categories including *a personal*

*understanding of what ethics means*, *learning ethics*, and *applying ethics in the workplace.* The fourth unanticipated category that surfaced, *academic integrity* raised further questions of ethical action within the program and how this impacts perspectives on ethical choices and right action as a professional. In the next chapter I will analyze the findings and draw conclusions from these observations, then consider recommendations for areas of curricular reform in professional university Engineering programs.

# CHAPTER 5: ANALYSIS

## Introduction

This study considers the experiences of recent graduates (alumni) from the Bachelor of Engineering Program at the University of Victoria, focusing on their description of learning ethics and equity from the vantage point of their current professional capacity. In this undertaking, two research questions were framed:

1. How do recent graduates describe their experience of learning ethics in the UVic B.Eng. program, while making meaning of their professional work in terms of ethics and equity?
2. In relation to effectively teaching ethics and equity in the B. Eng. curriculum what can we learn from the experience and practice of recent graduates?

In the findings of Chapter 4 the participants' descriptions of their experiences (in the form of transcripts) were analyzed and codified into three emergent categories which address the research questions: first *a personal understanding of what ethics means;* second *the experience of learning ethics;* and third *applying ethics in the workplace.* A fourth category, which was unforeseen, but inextricably linked to learning ethics – *academic integrity* – arose from the interviews and pursuant discussions. This chapter will provide an analysis of these four categories in terms of 1) how participants provided responses to the research questions; and 2) what kind of curriculum or curricular components they support or show a need for. This analysis is conducted with a view to discovering suggestions for curricular and pedagogical changes.

## A Personal Understanding of Ethics and Equity

### Answers to research questions: Normative approach

The manner in which the participants discussed what ethics and equity meant to them focused on a normative approach of following rules or technical codes. This is understandable given that most of their association with the topic of ethics is grounded in the EGBC Code of Ethics (EGBC, 2016). Earlier in this study, the pace of technology and the interpersonal skills required in today's business world were suggested as challenges for anyone dealing with a professional ethics dilemma. Participants in this study expressed their understanding and experience of engineering ethics education and revealed a somewhat superficial knowledge of ethics and equity on a personal and professional level. When discussing what ethics means to them, the participants focused a lot on fairness, gender, equity, and safety, with one participant claiming to have learned more about ethics and equity on Co-op work terms than he did in any classes he could remember.

### Curriculum connection: Defining ethics and equity

The participants' limited personal understanding of the meaning of ethics and equity provides an insight into the limited prefatory learning of ethics and equity from the B.Eng. program. The responses speak to the need in the Engineering program for an unequivocal explanation of *ethics* and *equity* at the foundational level, clearly differentiating the two. In the introduction to this study ethics is defined as a code of behaviour, or set of guidelines and rules for distinguishing between right and wrong. These rules are often defined by a particular group (like engineers) for other members of that group, as there is no universally accepted set of such rules, meaning that equivocation can be a common issue in a mutual understanding of ethics. This equivocal

nature of ethical issues offers up an occasion to teach young engineers the autonomous critical thinking skills required for effectively navigating the ambiguous landscape of ethical decision making in their professional work. Equity often refers to fairness or equality, and for this study equity is expressed as meaning both equality and fairness together. An important concept in understanding equity is the idea of privilege, and the early-in-program learning opportunities could be used to make engineers aware of their privileged place in society, as a foundation to learning about the social responsibility that comes with the rights of being an engineer.

Perhaps inclusion in the first-year courses of curricular components that better establish an initial understanding of *ethics* and *equity* respectively, on a personal and professional level, would serve this purpose. These components should require students to articulate their own meaning of the terms and how they intersect with one another in the decision-making processes of engineers solving problems.

## The Experience of Learning Ethics and Equity

### Answers to research questions: unmemorable impressions

When discussing his experience of learning ethics and equity at UVic, one participant stated that for him ethics "…wasn't treated with as much respect as I think it could have been...it was more sloughed off and it was deemed not as important as the true science itself". This leads one to question whether the idea of separating out the subjects (ethics, calculus, physics…) is problematic for ethics, and encourages seeing ethics as a tangential issue in engineering education rather than an integral part of the pedagogy and value structures. The use of the term "true science" in this statement is also revealing as to how this young professional sees ethics and equity in relation to the technical work undertaken, remembering that this was in the context of discussion on the actual learning

experience in the Engineering program. Between examples of ethics and equity not being given the same academic importance as more technical areas of study, and poor role-modeling (by virtue of a lenient approach to issues of academic integrity), the participants spoke highly of their overall experience of learning at UVic Engineering – but did not feel that the ethics and equity learning occasions had made much of an impression on them.

**Curriculum connection: Alternative approaches**

The confusion as to whether they were learning ethics or equity, or both, persisted in discussion of the learning of ethics and equity, and identified the *need* to ask how the curriculum or pedagogy may change to better facilitate the required learning. Alternative pedagogical approaches such as an in-class dialogue, requiring preparation and participation on the students' part, could be conducive to better comprehension and application of the ethics and equity learning. By discussing case studies of ethical dilemmas in the classroom, the students could be practicing their communication skills and gaining confidence doing so, while learning to debate a contentious topic and finding compromise. An example of such a case study might be the 2015 Volkswagen emissions scandal, which opens an opportunity for discussion of truthfulness in marketing and business. By bringing ethical considerations into technical courses students would learn to apply ethics more directly to their work and also learn to value ethical analysis as part of their problem analytics. For example, in a Thermodynamics class (which considers the transformation of energy and how it interacts with matter), an ethical concern may be the issue of *planned obsolescence* in heat exchangers (even as basic as a kettle), and how this creation of waste might have more to do with business than engineering.

## Experiences of applying Ethics and Equity in the Professional Workplace

### Answers to research questions: Professional concessions

Today's professional engineering workplace can pose challenges between choosing right action or increased profits, so why should an engineer even care whether to act ethically or not (besides liability)? First, a practicing Professional Engineer is required to adhere to the licensing body's code of ethics and uphold the reputation of their Profession in a manner prescribed by that code of ethics. The strong reputation of Engineering being a reliable profession can have a far-reaching impact on all Professional Engineers and their business dealings. Second, an engineer will build an individual professional reputation through their industry, sector and work, and as such, acting ethically can impact the prospects of future work or contracts within that marketplace. There is also the issue discussed earlier that simply by virtue of calling oneself a Professional there is an inherent responsibility to behave in a manner becoming of that title. This area of inquiry is also where one of the research participants expressed that sometimes a coworker "…is very unethical in the workplace, but they are so amazing at their job that you kind of have to close your eyes…" to the unethical behavior. This acceptance that in the engineering world there are people who have the technical and scientific skills to excel, but do not have the interpersonal skills to be inclusive, equitable, or even considerate of their coworkers, is (I believe) fundamental to the lack of emphasis given to ethics and equity learning. An apparent reverence for a person's mathematical and applied science skills appears to surpass the motivation for acting ethically, to the point that engineers are willing to make concessions in their professionalism that they would not make in their technical work.

**Curriculum connection: Attitudes and behaviour**

If engineers can get the work done faster and not care about interpersonal skills or being ethical – with no consequences – what motivation do they have to behave ethically? An essential step in dealing with ethical dilemmas in the workplace is the ability to recognize whether/when one is dealing with an ethical dilemma or not. This ability is the starting point for addressing these challenges in a fair and equitable manner. Systems of behavior and value systems in our corporate world often revolve around marketing and maximizing profits, so ethical behaviour is often the area that is compromised for these reasons, and therefore can cause professional career challenges for engineers. From a curricular and pedagogical standpoint, these stories invoke the question of why faculties of engineering don't pay more attention to attitudes and behaviours rather than focussing so strongly on content and facts? I believe it will take a more integrative approach towards ethics and equity curriculum and teaching in order to shift this way of thinking. What is at stake is the learning and development of young professionals entering into a work world where ethical decision making is becoming more difficult and more urgent.

A Professional Engineering program is responsible for explicitly addressing ethics learning issues, rather than hoping graduates will gain insight once working as a professional, and this appears to be a curricular area with a lot of scope for improvement.

## Academic Integrity as a Context for Learning Ethics

This unexpected finding has proven to be a core issue and an integrating factor for the other three categories (*meaning of ethics, learning ethics, and ethics in the workplace*), because the issue of cheating when one is learning ethics and equity, does not bode well for effective learning in this area. The UVic Engineering faculty has published a manual "Standards for Professional Behaviour", and this is introduced to students in *ENGR130: Introduction to Professional Practice* (UVic Engineering, 2000). This guide to academic integrity and professional behaviour is something students will encounter several times throughout the program; it is included with course outlines in some departments.

### Recollections of cheating while learning ethics

The research questions for this study focus on what can be learned from participant feedback as to improvement of the ethics and equity curriculum at UVic Engineering. The realization that every participant brought up issues of academic integrity without any direct questions on this area of concern is telling in as much as it implies that when thinking of ethics and equity learning at UVic Engineering one readily available memory was of an instance of cheating or of cheating being leniently dealt with. This, along with the participants' comments as to the lenient reaction from the B.Eng. program gives the impression that these young professionals learned more in the program about "when" to be ethical, than they did about "how" to be ethical in their professional work.

### Literature connection: Cheating in Engineering Programs

The findings in Chapter 4 included mention of the common occurrence of cheating in engineering programs. Smith, Bens, Wagner, and Maw compiled a literature

review of cheating in engineering and conducted a study at the University of Saskatchewan (Smith, Bens, Wagner, & Maw, 2016). Their finding that engineers are quite comfortable admitting to cheating seemed to match the comments made by this study's participants that they cheat as a time management strategy because of the heavy workload in the program. This connection to the literature reinforces the impression that the learning is more about when/how to cheat rather that whether to cheat.

**Curriculum connection: Across the discipline electronic learning portfolios**

Participants' attitude towards academic integrity seems to reflect the relative nature of their attitude towards ethics and equity in general. They rationalized cheating, saying that it was in order to deal with the heavy course load, some participants even questioned the rationale for a heavy course load as a strategy to reduce their own responsibility as a student, and place the responsibility for cheating with the Engineering program. The comments that the UVic Engineering program is too lenient on issues of academic integrity further support the literature that engineers are not ashamed to admit that they will do anything (even unethical things) in order to mitigate a problem or expedite a solution. An issue that arises from this last category - and participant comments - is whether a broader *across the discipline* and integrated approach to teaching ethics and equity to engineers may be more effective, and may help to address the academic integrity issues. This may include curricular and pedagogic strategies such as digital learning portfolios, or integrating journals to connect academics with work experiences. In professional programs (such as Engineering, Education, and Nursing) the goal is for the students to develop knowledge, skills and attributes that prepare them to work as professionals, with the inherent responsibilities that come with professional work. The process of collecting artifacts into an electronic portfolio offers a platform for

ongoing reflective practice and the intentional development of self-regulating skills and a professional identity. Sanford and Hopper (2010), in their study of using ePortfolios (ePs) in a professional teacher program, explain that "[a]s students develop their ePs they become better able to reflect upon where they need to grow in their learning…and more explicitly identify their sense of self as 'becoming' teachers …recognize[ing] the need to know themselves in order to develop as [professional] teachers" (Sanford & Hopper, 2010, p. 95). These ePs could serve as a cross cutting integration platform where engineering students can collect data and artifacts that helps them to define their professional potential in a comprehensive manner, including technical, social, and ethical learning.

## Conclusion

This research has brought attention to four categories associated with learning ethics and equity, which emerged from the data analysis: *a personal understanding of what ethics means; the experience of learning ethics; applying ethics in the workplace;* and *academic integrity*. All these areas address the research questions in a manner revealing attitudes towards and comprehension of ethics and equity learning gained through participation in the UVic B.Eng. program (which is accredited by the CEAB). This chapter's observations and suggestions connect the data analysis with the current delivery (curriculum and pedagogy) of the program in a manner that allows for the development of suggestions for curricular improvement.

# CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

## Conclusions

Given that the Cambridge Handbook for Engineering Education considers *ethics* a crosscutting issue in engineering education (along with *communication* and the *use of information technology*), (Johri & Olds, Cambridge Handbook of Engineering Education Research, 2014, p. 599). The participants of this study provide evidence that they do not necessarily see it that way. The remarks about cheating on homework as a time-management strategy, along with a superficial understanding of the terms *ethics* and *equity*, speaks to a reality being that ethics is seen (by the learners) as a side issue. The poor recollection of the ethics and equity curriculum or pedagogy at UVic Engineering suggests that the curriculum and pedagogy could benefit from some form of review and renewal or perhaps it speaks to a broader structural issue around how engineers are taught to be professionals, to be more than technical cogs in a mechanical system.

This is not just the case at UVic (where this case study was carried out) but appears to also be the responsibility of the Canadian Engineering Accreditation Board (CEAB), who are committed to continuous improvement of Canadian engineering curriculum and of the accreditation process itself. Since UVic's Bachelor of Engineering programs are accredited by the CEAB, this study will make recommendations that are pertinent to the UVic program but will also have relevance to all engineering programs in Canada. This relevance may also extend to ethics and equity learning for professional programs in other disciplines.

From the description of the current curriculum for ethics and equity learning at UVic Engineering it is apparent that UVic uses a multi-faceted approach to engineering ethics and equity education. Within the discipline are courses such as *ENGR130:*

*Introduction to Professional Practice; and ENGR120: Design and Communication II*. Of concern is the fact that the former (ENGR130) is developed and taught by professional staff from the Engineering Co-op office, with no direct involvement of Engineering Faculty members. The latter (ENGR120), is developed and taught in collaboration between the English Department (in the Faculty of Humanities) and a UVic Engineering Professor for the design components. The mandatory second year ethics course – *ENGR297: Technology and Society*, is developed and taught primarily by Professors from the Philosophy Department (also in the Faculty of Humanities). So, it appears that UVic's multi-faceted approach includes *within the discipline*, *outside the discipline*, and considerations of *societal implications of technology*.

## Recommendations

Based on the analysis of the data from participants, an understanding of the CEAB curricular requirements and graduate attributes, and knowledge of the UVic B.Eng. program, curricular improvement considerations and recommendations are developed in two areas – one, *curricular strategies* for better addressing ethical and equity issues and two, *pedagogical strategies* for greater focus on teaching ethics and equity.

### Curricular strategies for enhanced understanding of ethics and equity

One consideration raised in conversation with some participants is whether the UVic B.Eng. program would be better delivered if it was extended to be a five-year program, thus facilitating the inclusion of more courses or learning opportunities where required. The mandatory co-op program at UVic already extends a learner's experience to five years, so adding more time would be a challenge insofar as the program may stretch into a sixth year when considering applied experience gained through completion of the program.

Another consideration is to undertake a course redesign for *ENGR130: Introduction to Professional Practice* to include a more robust foundational ethics and equity curriculum for better developing an early understanding what ethics and equity mean, both personally and professionally. Potentially including the participation of an Engineering Faculty member on the ENGR130 team (rather than delegating it completely to the Co-op office) would facilitate the inclusion of ethics and equity learning in the context of technical engineering work, rather than the current emphasis on employment-readiness in this course. This would provide a pedagogical robustness that better matches the claims made that ENGR130 is an introductory and developing course for learning ethics and equity (see Appendix 2). For example, a Faculty member could facilitate a discussion of the ethical implications of accurate safety factoring in the design process. This course could also include a more detailed treatment of the meaning of the terms *ethics* and *equity*, before considering codes of ethics.

It is evident from the experiences of the participants of this study that skills in professionalism and ethical decision making, need to be raised and valued more integrally in the Engineering program, by administrators, educators, and learners alike. By taking an *across the discipline* approach to ethics and equity learning, students could be provided with a range of opportunities to display evidence (through co-op and coursework) of a deeper understanding of ethics and equity issues and how they have applied their professional skills in dealing with these issues. In a meeting with UVic Alumna, and a Director with Apple, Shaan Pruden, I heard her say that a valuable part of her Co-operative Education experience with UVic Engineering was the presentation she had to make when returning to studies after a technical work term. “Both the public speaking skills and the ability to articulate my accomplishments … has been one of the

most important skills for my career success" (Conversation, November 26, 2014). Due to the quantity of students now studying engineering at UVic, those presentations have been replaced with a written technical report. Another vehicle for students learning to articulate their perspectives might be an ePortfolio, or a short video resume.

As seen in the conclusions above, the UVic program currently utilizes this multi-faceted approach including *within the discipline*, *outside the discipline*, and considerations of *societal implications of technology*, via the courses claiming ethics and equity learning occasions. An added recommendation is that of taking a more *across the discipline* approach with ethics and equity curriculum – meaning integrating considerations of ethics and equity into technical curriculum. For example, by developing a planning strategy or other curricular components for professors, as a tool by which to integrate ethics and equity learning into their technical courses. This tool could include required competency levels for demonstrating a comprehension of the meaning of ethics and equity before embarking on a co-op technical work term, and outline pedagogic approaches for integrating ethical discussions into technical syllabi. Another curricular component that holds potential for adopting an *across the discipline* approach would be the consideration of using a digital learning portfolio, so as to facilitate iterative learning and reflection over the course of the program rather than the current course by course, and semester by semester approach. Virginia Polytechnic incorporated ePortfolios in their engineering program, and found that the developmental, evaluative, and presentational aspects of the ePs provided effective across the curriculum learning and the improvement of self-assessment skills (Knott, et al., 2005).

A final recommendation is the potential of using a capstone professional development course as EIT preparation for 3$^{rd}$ or 4$^{th}$ year students. It is evident by the

participants' comments that there is a need for a better understanding of the differentiation between being professional and being a Professional. One can behave professionally without being a Professional, but one cannot be a Professional without behaving professionally. By better aligning the ethics and equity learning in the B.Eng. program with the required ethics and equity learning in the Professional Practice Exam (PPE), the gap between undergraduate ethics and equity learning and the professional practice requirements of ethics and equity knowledge could potentially be narrowed.

**Pedagogic strategies for improvement**

Engineering courses can present ideas and concepts that require mathematical engagement without necessarily considering the application of these ideas in the real world. Perhaps the use of dialogic exploration in class rather than lecture would encourage students to address the relevancy of their mathematical knowledge in real world applications. This might involve using Socratic dialogue, initially between students and the educator (until they develop a competence), and then between the learners themselves, but moderated by the instructor. The back and forth discussion that constitutes a Socratic dialogue would facilitate the learning suggested by participant Jim who said "*I learned most about ethics [when] we had debates, and I think it is the best way to learn about ethics, because you learn that there are different opinions than yours and that there are different ways of looking at life*". Tolerating and respecting opinions that differ from theirs is also the basis for learning equitable attitudes and behavior. Genova and Gonzalez (2015) discuss using Socratic dialogue in teaching ethics to engineers in Spain and Chile, and acknowledge that this approach to teaching ethics engages the students and "…show[s] that the scientific world view…is insufficient when it comes to addressing ethical issues" (Genova & Gonzalez, 2015, p. 579). Similarly,

Goswami and Chakraborty (2015) discuss using ethics learning to "sensitize[e] engineers" to the responsibilities they hold towards society, concluding that "…ethical awareness makes the engineers conscious of their roles outside their office and they realize the power they have in transforming lives through innovation and design", they realize their privilege (Goswami & Chakraborty, 2015, p. 4).

An *intentional* consideration of learning occasions throughout the program for *professional identity formation* could help to identify opportunities for integrating ethics and equity learning *across the discipline*. This is supported by the use of ePortfolios in engineering design courses, piloted by Clemmer et al at the University of Guelph, which proved effective in facilitating learning, and increasing students' levels of insight through reflection (Clemmer , et al., 2015). Using electronic learning portfolios via an *across the discipline* approach would create a vehicle by which the learner might also gain professional identity formation learning throughout their program, thus helping to build connections between the theoretical and applied nature of their engineering practice. (Knott, et al., 2005)

This study has repeatedly found that the categorizing of ethics and equity together in the CEAB's 12 Graduate Attributes is problematic insofar as the understanding of both terms equally. It is problematic in that learners and educators alike place more emphasis on ethics than on equity – not giving them equal weight. Even as the researcher and author of this study I found myself easily omitting equity and focusing more on ethics. With equity being a domain which is particularly important to engineering (where the large majority of students are male), the CEAB and accredited B.Eng. programs may consider finding ways to better ensure that equity is included in the curriculum covering this graduate attribute. Can ethics and equity be considered conjointly in a manner that

reduces the diminished awareness of equity, or should equity be a separate graduate attribute completely?

Given the ongoing equity efforts by Engineers Canada to increase the number of women in Engineering, with initiatives such as the 30 by 30 campaign (aiming for 30% female engineers by 2030 – currently 17.5%), one would anticipate a comprehensive explanation of the learning outcomes required for graduate attribute number 10, ethics and equity, ensuring that these (mostly male) professionals appreciate their place of privilege, and the importance of fairness and equality (Engineers Canada, 2017). This is however not the case, with the CEAB's description of graduate attribute number 10 being the most cursory of all graduate attribute learning outcomes, simply stating "*An ability to apply professional ethics, accountability, and equity"* as the requirements for this attribute (see Appendix 3). This vague expression of the competency development required for ethics and equity has the potential to directly and negatively impact attitudes towards ethics and equity learning by educators and learners alike.

## In Conclusion

The technical course load in a Bachelor of Engineering program can be very high, making the pragmatics of fitting in ethics and equity learning (or courses) difficult (Newberry, 2004). So, teaching and learning these skills in professionalism can take on a secondary role, being a simple by-product of doing the technical projects in teams, via problem-based learning, with little opportunity for integrating intentional ethics and equity learning within technical learning. Participants expressed that their recollection of learning ethics and equity was centered around their co-op work terms where they were applying their technical knowledge in real world scenarios.

When these Engineers in Training qualify to register as Professional Engineers they will be required to write the Professional Practice Exam (PPE) adjudicated by Engineers and Geoscientists of British Columbia (EGBC, 2018). The PPE is based on national guidelines followed by all provincial engineering regulatory bodies, and includes 100 questions on a range of topics. These topics include the Codes of Ethics; Intellectual Property (copyrights, patents, trademarks); Safety; Law; Member Discipline Processes; and an understanding of Professionalism (APEGA, 2017). While the standards for an understanding of ethics and professionalism in the PPE are quite robust, it is noteworthy that the PPE does not appear to include any reference to understanding issues of *equity* (APEGA, 2017). So, while emerging Professional Engineers *do* appear to cultivate an understanding of ethics applied in their professional practice, there appears to be different standards for considerations of *equity*. This appears apropos with the lack of curricular robustness around equity in the CEAB requirements, and in the curriculum of accredited Engineering programs. These participants' limited understanding of ethics will be further developed through their professional practice, ongoing professional development, and participation in the PPE. Their limited understanding of *equity,* however (it appears) may not be addressed through these vehicles, but will rely on their own personal interests. It does therefore appear that the CEAB's inclusion of equity in graduate attribute number 10, and perhaps even Engineers Canada's 30 by 30 initiative, may be mere lip service and reveals a broader apathy toward equity when it comes to curriculum and professional practice guidelines.

The way the participants of this study discussed their experience of learning ethics and equity in the B.Eng. program demonstrated that their understanding of these two areas of learning was limited and difficult to recollect. Through the discussion of their

experiences these graduates of the UVic program have revealed opportunities for curricular reform. These include an integrated across the discipline approach to teaching ethics and equity, using cross cutting curricular components such as electronic learning portfolios; a clearer foundational understanding of the meaning of ethics and equity respectively; and a need for more dialogue based pedagogy, through debates on ethical case examples. The conclusions and recommendations discussed in this final chapter offer ideas for consideration on refining the curriculum, but are limited to the scope of this study, the data from participants, and the knowledge base of the researcher. The need for further study of these curricular reform opportunities is evident, and in order to adequately equip young professional engineers in today's fast paced technologically advancing society, new integrated approaches to teaching knowledge, skills and attributes in *ethics* and *equity* will be necessary. "Students preparing to become professionals must learn to determine their strengths and areas needing further development for them, rather than relying on an external authority to direct their future learning", and ePortfolios are an effective tool for this purpose (Sanford & Hopper, 2010, p. 95). Self-regulation will be essential to their successful ongoing professional development, and will require that they learn to think reflectively, accurately self-assess, and authentically focus on their continuing improvement as Professional Engineers.

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# Appendix 1

## Master's Degree Research Project On B.Eng. Graduates' Experience Of Learning About Ethics And Equity at UVic:

**Dear Recent Graduate/ Engineer in Training:**

My name is John Fagan, a Masters candidate in the department of Curriculum and Instruction, at the University of Victoria. I am currently conducting a research project as the principal investigator to fulfill partial requirement for my Masters degree in Curriculum and Instruction for Engineering Education. This study has received approval from the Human Research Ethics Board at UVic. (You can verify the ethical approval of this study by contacting the Research Ethics Office by phone at (250) 472-4545, or by email at ethics@uvic.ca.)

This study will consider the experiences of recent graduates from UVic Engineering, particularly how you learned about ethics and equity, whether in a class, a lab, on a work term, a student group, or in any other activities undertaken while completing your engineering degree. Participation will involve a one-hour interview with myself, this will be semi structured and should feel more like a conversation. Your story will be audio recorded so that I can transcribe it into text in order to analyze the various stories for common themes and experiences.
Participation in this study is limited to recent graduates and engineers in training who are currently employed, and is completely voluntary, meaning you are under no obligation to participate, and may withdraw at any time.

Please contact me at your earliest convenience if you are interested in participating in my research. I will be happy to answer any questions you might have concerning this research. I am available by phone at (250) xxx-xxxx and by e-mail at xxxxxx@uvic.ca .

I look forward to hearing from you.
Kind Regards

John Fagan
(250-XXX-XXXX,
xxxxxx@uvic.ca )

**Terminology and Reference:**

Since 2008 Engineers Canada and the Canadian Engineering Accreditation Board (CEAB) have been moving towards an outcome based assessment of engineering programs. Places you may have encountered this include the EIT application process. This process now depends on a competency assessment rather than the traditional Log Book. As part of this process the CEAB has established 12 Graduate Attribute areas for assessing engineering programs in Canada. An area of particular interest to me is #10 – Ethics and Equity, which has motivated me to look at the courses, co-op, and other learning opportunities you had in this area while doing your B.Eng at UVic.

| | |
|---|---|
| 1. Knowledge base for Engineering | 2. Problem analysis |
| 3. Investigation | 4. Design |
| 5. Use of engineering tools | 6. Individual and teamwork |
| 7. Communication | 8. Professionalism |
| 9. Impact on society/ environment | 10.Ethics and equity |
| 11. Economics/ project management | 12. Lifelong learning |

Below is a basic list of courses where you will have gained some learning around Ethics & Equity. If you completed any of these courses, please try think back to your experience and what you learned.

| Courses in which you may have encountered learning on Ethics & Equity at Uvic B.Eng: | | | |
|---|---|---|---|
| | Introductory | Developing | Advanced |
| SENG | ENGR130/120 | SENG360/321/371 | SENG401 |
| ELEC/CENG | ENGR130/120 | ENGR297 | ENGR446? |
| MECH | ENGR130/120 | ENGR297/MECH350 | ENGR446? |
| BME | ENGR130/120 | ENGR297/BME350 | ENGR446? |

**Interview questions:**

1. Tell me about your experience of studying engineering at UVic?
2. How do you describe yourself when someone asks “what kind of engineer are you”?
3. What does ethics and equity mean to you?
4. How would you define your personal/work ethic?
5. Tell me about an experience at UVic helped you most in learning about and understanding ethics and equity, and why? (courses, student groups, co-op work terms, conversations).
6. How have these experiences contributed to your understanding of ethics and equity as a professional engineer in training?
7. Tell me (in broad terms – to maintain confidentiality) about an ethical challenge you have faced in the workplace, and how you dealt with this? …and what equipped you to deal with this?
8. Please tell me about your Ethics & Equity learning in any of the courses listed above?
9. Tell me about your experience of studying at UVic (from the perspective of “ethics”) …what worked, what did you disagree with, what moral/fairness/equity issues (if any) did you experience?
10. Any other stories from your experience that are relevant for this area of learning for engineers?

# Appendix 2

**University of Victoria Engineering Program Mapped Indicators for Ethics and Equity Graduate Attribute #10:**

| Program | Indicators | Introductory courses | Developing courses | Advanced courses |
|---|---|---|---|---|
| MECH | Demonstrate the ability to apply the Code of Ethics in real world situations | ENGR120<br>ENGR297 | ENGR130<br>ENGR297<br>MECH350 | |
| MECH | Demonstrate the ability to negotiate compromise in conflict situations while respecting the rights of all parties involved | | ENGR297 | |
| MECH | Demonstrate the ability to willingly subject one's work to the scrutiny of colleagues and the general public | | MECH350 | |
| SENG | 27. Demonstrate the ability to recognize ethical and equity based dilemmas | | | |
| SENG | 27.1 Understand the responsibility of a professional engineers with respect to ethics and diversity | ENGR130 | ENGR120 | SENG401 |
| SENG | 27.2 Understand the responsibilities of an engineer to society | ENGR130 | ENGR120 | SENG401 |
| SENG | 27.3 Articulate the issues involved in ethical and equity problems | ENGR130 | ENGR120 | SENG401 |
| SENG | 27.4 Exhibit behaviour consistent with academic integrity expectations | ENGR130 | ENGR120 | SENG401 |
| SENG | 27.5 Demonstrate sensitivity to cultural and gender issues | ENGR130 | ENGR120 | SENG401 |
| SENG | 28. Demonstrate the ability to apply the Code of Ethics and equity principles | | | |
| SENG | 28.1 Understand and apply APEGBC's Code of Ethics | ENGR130 | ENGR120 | SENG401 |

| | | | | |
|---|---|---|---|---|
| SENG | 28.2 Understand and apply Software Engineering Code of Ethics | ENGR130 | ENGR120 | SENG401 |
| SENG | 28.3 Understand software security policies, legal requirements, and ethical issues | | SENG360 | |
| SENG | 28.4 Appreciate the challenges with respect to equity and diversity in requirements engineering | | SENG321 | |
| SENG | 28.5 Appreciate the ethics involved in software reverse engineering | | SENG371 | |
| ELEC, CENG | Apply the code of ethics in real world situations and recongize ethical and equity based dilemmas | ENGR 130<br>ENGR 120 | ENGR 297 | |
| BME | Demonstrate the ability to apply the Code of Ethics in real world situations | ENGR120<br>ENGR297 | ENGR130<br>ENGR297<br>BME350 | |
| BME | Demonstrate the ability to negotiate compromise in conflict situations while respecting the rights of all parties involved | | ENGR297 | |
| BME | Demonstrate the ability to willingly subject one's work to the scrutiny of colleagues and the general public | | BME350 | |

# Appendix 3

**Consultation Group – Engineering Instruction and Accreditation Graduate Attributes:**

3.1.1 A **knowledge base for engineering**: Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.

3.1.2 Pr**oblem analysis**: An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.

3.1.3 **Investigation**: An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.

3.1.4 **Design**: An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.

3.1.5 **Use of engineering tools**: An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.

3.1.6 **Individual and team work**: An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.

3.1.7 **Communication skills**: An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.

3.1.8 **Professionalism**: An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.

3.1.9 **Impact of engineering on society and the environment**: An ability to analyze social and environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.

3.1.10 **Ethics and equity**: An ability to apply professional ethics, accountability, and equity.

3.1.11 **Economics and project management**: An ability to appropriately incorporate economics and business practices including project, risk, and change management into the practice of engineering and to understand their limitations.

3.1.12 **Life-long learning**: An ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge.