Published in final edited form as:

Sci Eng Ethics. 2017 April ; 23(2): 591–622. doi:10.1007/s11948-016-9781-2.

Engineers' Responsibilities for Global Electronic Waste: Exploring Engineering Student Writing Through a Care Ethics Lens

Ryan C. Campbell and

Individual Ph.D. Program, Interdisciplinary Programs, The Graduate School, University of
Washington, 301 Loew Hall, Campus Box 352192, Seattle, WA 98195-2192, USA

Denise Wilson

Department of Electrical Engineering, University of Washington, 185 Stevens Way, Campus Box
352500, Seattle, WA 98195-2500, USA

Abstract

This paper provides an empirically informed perspective on the notion of responsibility using an ethical framework that has received little attention in the engineering-related literature to date: ethics of care. In this work, we ground conceptual explorations of engineering responsibility in empirical findings from engineering student's writing on the human health and environmental impacts of "backyard" electronic waste recycling/disposal. Our findings, from a purposefully diverse sample of engineering students in an introductory electrical engineering course, indicate that most of these engineers of tomorrow associated engineers with responsibility for the electronic waste (e-waste) problem in some way. However, a number of responses suggested attempts to deflect responsibility away from engineers towards, for example, the government or the companies for whom engineers work. Still other students associated both engineers and non-engineers with responsibility, demonstrating the distributed/collective nature of responsibility that will be required to achieve a solution to the global problem of excessive e-waste. Building upon one element of a framework for care ethics adopted from the wider literature, these empirical findings are used to facilitate a preliminary, conceptual exploration of care-ethical responsibility within the context of engineering and e-waste recycling/disposal. The objective of this exploration is to provide a first step toward understanding how care-ethical responsibility applies to engineering. We also hope to seed dialogue within the engineering community about its ethical responsibilities on the issue. We conclude the paper with a discussion of its implications for engineering education and engineering ethics that suggests changes for educational policy and the practice of engineering.

Compliance with Ethical Standards

Disclosure of Potential Conflicts of Interest

The authors declare that they have no conflict of interest.

Research Involving Human Participants and/or Animals

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

Informed Consent

Informed consent was obtained from all individual participants included in the study.

Keywords

ethics of care; feminist ethics; electronic waste; electronics recycling; engineering education; engineering ethics

1. Introduction

Engineering and technology have changed the lives of many people on this planet. However, technical solutions are not the value-neutral panaceas we might imagine them to be (e.g., see Latour 1992; Friedman 1996; Franssen et al. 2013; Pesch 2015). If we as engineers do not know, understand, articulate, or discuss the values that are driving our efforts, then we are far less likely to create lasting solutions to the problems we hope to address. In fact, engineers may have inadvertently helped to create many of the problems that plague the world today, such as those associated with environmental pollution and anthropogenic climate change. Without examining our values and perhaps even adopting new ones, we may continue creating as many new problems as we solve. However, the changes that are necessary for the engineering profession to seriously reflect on its values and adopt new ones will not happen easily.

In this paper, we contribute to the thought and dialogue needed to create change in the value system of engineering by exploring an ethical framework that has received little attention in the engineering-related literature to date. Care ethics, also known as ethics of care, is a normative ethical theory emphasizing care, compassion and context rather than impartiality and universal standards. Compared to conventional ethical frameworks of consequentialism (e.g., utilitarianism) and deontology (e.g., duty- or rule-based ethics), care ethics provides a shift in moral perspective from asking “what is just?” and instead asks “how to respond?” (Gilligan 1995). Care ethics addresses missing dimensions in conventional ethical thinking by accounting for real-world differences in power and dependence, and by giving additional consideration to those who are vulnerable or disadvantaged (e.g., it targets equity rather than presuming equality). While care ethics might not be the only ethical framework needed in a given situation, to neglect the considerations that care ethics provides in favor of other frameworks opens the door to oppression and injustice. As Tronto (1993, p. 147) wrote: “a moral theory that can recognize and identify these issues [e.g., privilege, paternalism, parochialism] is preferable to a moral theory that, because it presumes that all people are equal, is unable even to recognize them.”

To begin exploring engineering through a care-ethics lens, we situate this work in the context of the human health and environmental impacts of “backyard” electronic waste (e-waste) recycling that presently occurs in many industrializing countries, such as India and China (Sepúlveda et al. 2010). We believe that engineers have ethical responsibilities to address the e-waste problem, and that there are actions engineers can and should take, both inside and outside the traditional purview of engineering. However, the purpose of this article is not to argue this position directly, but to explore qualitatively, in terms of care ethics and using engineering student essays, how students in traditional engineering programs would respond to this problem. The e-waste problem serves as one instance of a

class of problems of a humanitarian or social justice nature for which care ethics is particularly well-suited.

This approach enhances critical understanding of the next generation of engineers who will soon be making decisions for the engineering field. Furthermore, through the introduction and explication of a care ethics framework as applied to engineering, the paper provides reflection on the purpose and responsibilities of the field of engineering, with implications for engineering practice and educational policy. These outcomes of the paper can be used to inform engineering course design, such as, by incorporating new ethics and social justice issues into traditional engineering and/or “humanitarian engineering” programs, as well as to suggest broader curricular changes beyond the existing terms of mainstream discussions on curricular content and pedagogy.

1.1. Ethical Responsibility in General

Much has been written on the subject of responsibility in a moral or ethical sense¹ (e.g., see Eshleman 2014; Fischer and Ravizza 1998; Frankfurt 1969), though it is well beyond the scope of this work to review all such literature. In the field of applied ethics for the disciplines of science and engineering, a search of all issues of Springer’s journal of *Science and Engineering Ethics* (1,375 articles from 1995 to 2015) shows that variants of the words oblige and responsible (e.g., obligation, responsibility, responsibilities, irresponsible, etc.) occur in the titles of 128 articles. In the present paper, we contribute to this literature an examination of ethical responsibility among engineers by exploring engineering students’ positions on the responsibilities of engineers for the problem of e-waste.

1.2. Care Ethics

As indicated above, care ethics is a normative ethical theory that emphasizes care, compassion, and context rather than impartiality and universal standards. Care ethics has evolved as a distinct ethical theory in the academic literature in response to the work of feminist scholars of the 1970’s and 1980’s. Pioneering work by Gilligan (1982) in psychology was taken up by others, such as Noddings (1984/2003) in education, Kittay (1999) and Held (2006) in philosophy, and Tronto (1993) in political science. In the present work, we build on Tronto’s (1993) care ethics framework, which first describes care in terms of four interconnected phases: caring about, taking care of, care-receiving, and care-giving. Each of these phases then map to an ethical element: Attentiveness, Responsibility, Competence, and Responsiveness, respectively. A fifth meta-level element, Integrity, then integrates the four elements into a cohesive whole. Tronto’s framework for care ethics can be described as an interconnected and sometimes overlapping sequence of these five elements, as approximated by Fig. 1.

We chose Tronto’s framework because it facilitates understanding both analytically through comprehension of its individual elements, and synthetically through the integration provided by the Integrity element as well as the inter-relations between its other elements. Indeed, others have recognized the accessibility and structure of Tronto’s framework and elaborated

¹We use the terms moral and ethical interchangeably in this paper.

on it in engineering contexts, including Pantazidou and Nair (1999), who mapped the elements to the processes of engineering design and problem solving; Kardon (2005), who conceptualized the framework as a standard of care for engineering; and Van Wynsberghe (2013), who adopted it as a conceptual framework for doing value-sensitive design in the context of healthcare robotics. One of the present authors (Campbell 2013) articulated how Tronto's framework could be used to improve social justice outcomes in "humanitarian engineering" endeavors. In other work, we provided summaries of Tronto's framework as a whole (see Campbell, Yasuhara, and Wilson 2012; 2015).

Moving beyond Tronto's framework into the broader realm of care ethics in engineering, Riley (2013) illustrated, among other things, how key aspects of care ethics are sometimes "lost in translation" when engineers try to apply them (e.g., Kardon 2005). Sunderland (2014) showed the value of emotion in engineering ethics via problem-based learning and mentioned Pantazidou and Nair's (1999) work as drawing positive attention to emotion. Roeser (2012) also mentioned care ethics and even called for a reform of engineering curricula to include "courses that enhance the emotional and imaginative capacities of future engineers." Fruitful discussions of care ethics are also occurring in related fields, such as science and technology studies (STS) (e.g., see Bellacasa 2011), and business ethics (e.g., see Hamington and Sander-Staudt 2011).

The present work adds to the literature an empirically informed perspective in a different discipline (electrical engineering) and context (human health and environmental impacts of e-waste). It also focuses more deeply on a single element of the framework, Responsibility.

1.3. Care-Ethical Responsibility

In Tronto's view of care ethics, Responsibility is a "central moral category" (1993, p. 131). When a need is identified, one must decide if one feels responsible for it and if so, how to respond (p. 106). Responsibility in care ethics differs from other, more traditional notions of responsibility in five major ways.

First, it is not universal, but dependent on context: the best ethical response is a function of the situation and actors involved. Responsibility in care ethics considers both what should be done and what those involved are capable of doing. For example, in engineering, one might wish to claim universally that engineers are responsible for ensuring the things they design are safe to use; however, if the specified materials or components prove unavailable and alternatives are used during manufacturing or construction, how much influence is the design engineer capable of and how responsible should he or she realistically feel if the designed artifact fails?

Another difference between care-ethical and traditional notions of responsibility lies in the dimension of time. Responsibility in care ethics tends to be future-oriented rather than looking to the past and is thus concerned with getting things done (meeting needs) rather than placing blame. In the previous example of the design engineer, rather than examining fault or liability, responsibility in care ethics would help us focus on the nature and scope of the actions the design engineer could/should take, such as anticipating material/component compromises by suggesting suitable alternatives, adding warnings to the design

specifications regarding substitutions, and/or being involved in manufacturing or construction in some way that enables oversight of the materials used.

Furthermore, adopting a care ethics perspective also helps spotlight stakeholders who might otherwise be missed. A conventional ethical perspective might focus on causal responsibility, looking across the lifecycle from the design engineers and the companies for whom they work, to the consumers and eventual disposers of a designed artifact or system. These are stakeholders who actively influence a given situation. In addition to these stakeholders, responsibility in care ethics reminds us to consider stakeholders who are affected by the situation and to even prioritize the needs of disadvantaged (e.g., vulnerable, powerless, or underprivileged) stakeholders. These affected stakeholders could also have a role to play in addressing or preventing problems.

Another important aspect of responsibility in care ethics is related to the notion of responsibility ascription, i.e., deciding who is responsible. Care-ethical responsibility involves internal (personal and/or collective) volition rather than external compulsion. It is up to the individual (or group) to decide if they will assume responsibility for something, rather than having others externally impose that responsibility on them (e.g., by law, contract, or social pressure). It is thus a more aspirational approach to responsibility than that found in many ethical theories. As Tronto (1993, pp. 131–133) explains, whereas obligation means we have to do something as imposed by an external driver, responsibility means that we should do something regardless of any external compulsion.

Finally, in her more recent work, Tronto (2013, Chapter 2) made the point that individual responsibility is not enough: we have collective responsibilities that must be discussed and agreed upon collaboratively. This is especially pertinent in an engineering context to address such complex problems as those associated with “backyard” e-waste recycling. Tronto (2013, p. 63) suggests that a participatory, democratic approach to responsibility is needed to address the main pitfalls of care ethics, pitfalls known as paternalism, which involves some people assuming too much responsibility or authority, and parochialism, which involves setting the moral boundaries too narrowly and only taking care of our own concerns (see also Tronto 1993, p. 142 and 146).

With these differences between traditional notions of responsibility and care-ethical responsibility in mind, this study analyzes how students view the issue of e-waste in the context of this alternative view of responsibility provided by Tronto’s conceptual framework.

2. Methods

This section describes the methods used to collect and explore the data, beginning with the research question guiding the work. We then describe the source and selection of data,² and then conclude with a description of our approach to coding and analyzing the data.

²Portions of the Data Source and Data Selection sub-sections were adapted from Campbell, Yasuhara, and Wilson (2012), which reported on a pilot study using a slightly different data set, and Wilson et al. (2013), which used the same data set but for a different type of analysis.

2.1. Research Question

We were interested in exploring, in terms of care ethics, how students in traditional engineering programs respond to problems of a humanitarian or social justice nature. Specifically, the following research question guided this work: *How do students exhibit care-ethical responsibility in the context of “backyard” e-waste recycling?* Answers to this question might tell us whether or not students associate engineers with responsibility for this issue and the nature and scope of that responsibility. We were also interested in the associated implications, such as on teaching and learning engineering, educational research, and engineering ethics, including suggestions for educational policy and the practice of engineering.

2.2. Data Source

This work explores samples of student writing on the topic of electronic waste recycling in industrializing countries. These samples were written in 2011 by undergraduate students at a large public research institution³ in the western United States. Students from a variety of engineering majors in a large, entry-level electrical engineering course were provided with an article on the health and environmental impacts of waste electronics in China and India. They were also given three questions pertaining to the article and asked to write a short (one to two page) essay as guided by the provided questions (see below). The assignment was optional and students were incentivized with extra credit to be applied to their course grades. The students had 1 week to complete the assignment.

The article the students read was entitled “A review of the environmental fate and effects of hazardous substances released from electrical and electronics equipment during recycling: Examples from China and India” (Sepúlveda et al. 2010). Students were directed to specific portions of this 14 page scholarly article to read in detail, namely: (a) the half-page Introduction, which provided brief context and background of the e-waste problem; (b) the paper’s only figure, which depicted the ecological cycle and the fate of pollutants generated by e-waste recycling; and (c) the paper’s fourth section (a page and a half), which described environmental and health perspectives in China and India related to e-waste recycling activities. The following are the questions to which the students were asked to respond in their essays:

1. What part of Waste Electronics Recycling in the figure concerns you most? Why?
2. From the part of the Waste Electronics Recycling process you chose in Question 1, what is the impact on humans? On ecosystems? (address air, water, or food quality as needed/desired).
3. What do you think modern engineers producing these electronic technologies should do as an “ethical” response to the waste electronics recycling dilemma? Comment specifically on how far in scope engineers should go to limit this impact.

³This school is classified as a doctorate-granting Research University RU/VH (very high research activity) according to the Carnegie Basic Classification (2010).

In terms of Tronto's framework, reading the journal article and answering the first two essay questions encouraged care-ethical attentiveness to a problem that should inspire some level of caring. In this context, the third question (and the phrase "*ethical*" response in particular) then encouraged responses compatible with care-ethical responsibility.⁴ Thus, the third essay question was the focus of our analysis. Note that the students received no instruction in this course on the topic of ethics in general or on care ethics specifically. Our analysis thus provides a view of care-ethical responsibility that undergraduates might bring into the engineering classroom without prior study of, or instruction in, care ethics.

2.3. Data Selection

All students in the class were invited to complete the essay for extra credit, and (also optionally) to release their work for this research. Students were fully informed (verbally and in writing) that their grades would not be impacted by their decisions on consent; furthermore, details regarding who provided consent and who did not were withheld from the instructor. Out of the 180 students enrolled in the course, 101 completed the extra credit assignment. After removing ineligible essays (e.g., those that were missing consent forms or their authors explicitly chose not to participate in the study), 84 essays were available for analysis.

The students' demographics were also collected as part of an associated but distinct study (see Allendoerfer et al. 2012) that was administered concurrently with the written extra credit assignment described above. The majority of the available participants were male, U.S. citizens of age 18 to 22, majoring in electrical or mechanical engineering, in the third (junior) year of their program, and of white/Caucasian ethnicity. However, we wanted to explore a demographically diverse sample of the available data that would be more likely to exhibit a broader range of perspectives and responses. Therefore, an intentional sample was selected that oversampled for women and non-citizens. Additionally, the criteria of major, ethnicity, and age were used to achieve approximately proportional representations of each of these demographics from the available essays, thereby maximizing diversity to the extent possible across the available dimensions. The initial sample size was 17 essays, and 13 more were added after completing a portion of the analysis, bringing the total up to 30. The purpose of the second sample was to improve coverage of demographics, increase confidence in data saturation and thereby minimize the risk of misrepresenting the data. The total sample contained writing from 10 women and 20 men including 19 US citizens, 4 permanent residents, and 7 foreign nationals. Self-reported ethnicities in the sample included 12 white/Caucasian, 10 Asian/Asian-American, 3 under-represented minorities (including Hispanic/Latino/Mexican-American and black/African-American), and 5 with multiple ethnicities. Their majors were as follows: 12 in electrical engineering, 9 in mechanical engineering, 3 in industrial engineering, 2 in computer science/engineering, and 1 each in bioengineering, civil/environmental engineering, materials science/engineering, and

⁴As observed by an anonymous reviewer of this manuscript, use of the word "ethical" in the prompt makes the question less open-ended and less probing of student senses of responsibility than if the word had been omitted. We acknowledge this point. We also take this opportunity to invite the reader to consider whether the phrase "ethical response" might serve as lay-language for the notion of care-ethical responsibility.

mathematics. Age ranges covered in the sample included 18 to 20 years (11 students), 21 to 24 years (16 students), and 25 to 40 years (3 students).

2.4. Analysis Approach

In this work, we provide a qualitative view of what engineering students bring to the table in terms of care-ethical responsibility for the e-waste recycling problem. To achieve this, we performed two levels of analysis: the first was descriptive and provided a foundation upon which to build the second, more interpretive layer. Fig. 2 outlines the approach, which we explain in more detail below. For both layers of analysis, we sought to cover the diversity of responses rather than report quantity or prevalence of response types (though these are also reported incidentally). The unit of analysis was the individual essay, using the entire essay written by each student. Analysis involved first reading the essay and demarking responses to each of the three essay questions wherever they happened to occur.⁵ Coding was based on units of meaning found in the text, thus codes were applied to passages of variable length including phrases, sentences, and/or paragraphs where appropriate. Coding was performed using ATLAS.ti qualitative data analysis software. Essays were anonymized and referenced using participant code numbers during the coding process. Pseudonyms were later chosen and applied during the write-up. Note that, while essays were initially selected based on student demographics (i.e., the intentional sample described above), the reading and coding of student writing was performed without knowledge of these demographics.⁶ All quotations included in this paper were selected after coding, based on the following criteria:

- clarity of illustrating the code/category/idea
- coverage of a variety of different participants based on their survey demographics
- coverage of diversity (or breadth) of responses with respect to care-ethical responsibility

2.4.1. Descriptive Coding—The descriptive coding, summarized on the left half of Fig. 2, involved operationalizing care-ethical responsibility in two ways. One way provided a broad overview of all stakeholders that students mentioned in response to the third essay question, and the other provided more focus by examining who students associated with responsibility for the e-waste recycling problem. Each of these are explained in more detail below.

Coding for Stakeholders: This phase of the analysis involved reading through all responses to the third essay question (regarding ethical responses to the e-waste problem) and inductively coding the different stakeholders mentioned in each. Stakeholders were defined broadly as individuals, groups, institutions, or entities (including the natural environment)

⁵Most, but not all students followed the structure suggested by the numbered essay questions, and some included introductions and/or conclusions that addressed multiple essay questions.

⁶However, in a few cases, clues about certain demographics were found within the essay either directly, such as through statements indicating a student's home country, or indirectly, through writing styles indicative of English as a second language. Nevertheless, a conscious effort was made by the coder to bracket this knowledge so that it did not influence the coding process, especially during the more interpretive phase of the analysis, in case patterns related to participant demographics should emerge (see "Implications for Empirical Educational Research" in Section 5.2).

that are likely to affect or be affected by e-waste recycling/disposal. While the multiplicity and variety (i.e., breadth) of indicated stakeholders was the desired outcome, all direct instances of each stakeholder were coded to avoid missing any (pronouns were only coded if they clearly implied a stakeholder not previously stated). We expected this operationalization to provide insights into how well responsibility was being assumed inasmuch as the greater the number and/or variety of indicated stakeholders, the more likely that suggested or planned actions would positively impact the e-waste problem.

Coding for Who is Responsible: This coding pass focused on responses to the third essay question with an eye for who was associated with responsibility. Rather than coding inductively, here we looked for indications of engineers and/or non-engineers as being either positively, negatively, or ambiguously associated with responsibility. These codes are summarized in Table 1 below and were not mutually exclusive at the essay level, thus multiple applications of these codes across multiple passages were possible in any given essay. In this analysis, the distinction between participant uses of the words “can” or “could” versus the word “should” was not emphasized. While these words carry considerably different weight in any context of responsibility, with the imperative “should” holding a much stronger position than the more optional “can/could,” idiomatic manners of writing and variations in language fluency made such distinctions difficult to uphold. Given the question, “What do you think modern engineers ... should do as an “ethical” response...?” some students chose to respond with multiple suggestions for what engineers might do, listing possibilities with “can” or “could” rather than (or sometimes in addition to) identifying primary recommended actions. Rather than assuming (perhaps erroneously) that students made conscious and deliberate word choices in this regard, coding captured indications of both the normative “should,” which occurred in the strong majority of coded passages, along with indications of the possibilistic “can/could,” for which there were relatively few instances.

Reconciling a participant’s position on the responsibility of engineers for the e-waste recycling problem occurred in the next phase of the analysis as described in the next subsection. Note that, while the participants in this study were students and not practicing engineers, they were all majoring in engineering and thus likely aspiring to be engineers (even the math major, who had a second major in electrical engineering). Their statements about the responsibilities of engineers are therefore likely to reflect thinking about their own personal and professional values, rather than being statements that ascribe responsibilities to people other than themselves. We expected this operationalization to give insight into student conceptions of responsibility assumption⁷ and also to have implications on awareness of both the engineer’s power for action and limitations or constraints on that power.

⁷Use of the phrase “responsibility assumption” in this work is intended to be used interchangeably with the phrase “assumption of responsibility.” While the more common phrases of “responsibility acceptance” or “responsibility ascription” could also have been used, these were not chosen because the associated connotations of external assignment and blame are not consistent with the adopted care-ethics framework, which employs a more internal and voluntary notion of responsibility as described in Section 1.3 above.

2.4.2. Applying the Care Ethics Lens—In the second level of analysis, summarized on the right half of Fig. 2, we built on the descriptive coding results, applying the care ethics framework introduced in Section 1. This involved examining the variations both in stakeholders indicated and in acknowledging engineers' responsibility, which facilitated a preliminary, conceptual exploration of care-ethical responsibility within the context of engineering and e-waste recycling/disposal.

Variations in Stakeholder Considerations: This phase of the analysis involved further operationalizing care-ethical responsibility via stakeholder considerations. Specifically, we examined (a) the multiplicity and variety of indicated stakeholders (i.e., the more and the more diverse, the better) and (b) considerations of disadvantaged stakeholders (i.e., those who are vulnerable, powerless, or underprivileged), such as children or innocent people. We examined the data in this way to measure or assess the quality of care-ethical responsibility present in the essays.

Variations in Acknowledging Engineers' Responsibility: In this phase of the analysis, we built on the results of the "Who is Responsible" coding to arrive at a mutually exclusive categorization capturing each essay's position on the responsibility of engineers for the e-waste problem. This involved first making logical inferences based on the "Who is Responsible" coding,⁸ and then re-reading student responses to the third essay question (plus any related text necessary to understand context, pronouns, etc.) this time with an eye for discourse rather than content. Here we sought to capture the manner in which responsibility was expressed, as manifest by indications of limitations on engineers' responsibility and/or the sharing of responsibility with others. This was an iterative process that ultimately led to the categories of essays shown in Table 2 below. These categories were mutually exclusive at the essay level.

3. Preparatory Findings (Descriptive Coding)

In this section, we present the coding results, independent of Tronto's conceptual framework of care ethics. The purpose of this phase of the analysis was to provide a descriptive, "close to the data" portrayal of student responses upon which the more specific, care ethics findings of the next section could build.

3.1. Stakeholders (Descriptive Coding Results)

Students indicated a variety of stakeholders in their responses to the third essay question. Stakeholders were broadly defined as individuals, groups, institutions, or entities, including the natural environment, who students perceived as likely to affect or be affected by e-waste recycling. These stakeholders were then classified into the following four broad categories:

- The Technical/Economic category included specific groups, such as engineers, electronics companies, manufacturers, and consumers of electronics, as well as companies and/or individuals involved in the recycling of e-waste. Some of these

⁸For example, the second and third categories of Table 2 were applicable to essays in which both engineers and others were associated with responsibility (i.e., contained at least one instance of "Engineers responsible" and "Others responsible" from Section 2.4.1).

stakeholders were specified as being in either industrialized or industrializing (also known as “developing”) regions, though many were ambiguous in this regard. Broader entities were also mentioned, such as the electronics market and the economy. Infrequently mentioned stakeholders in this category included scientists, businesspeople, sellers of electronics, and the electronics industry.

- The Citizenry category also included specific groups, such as children and future generations, as well as broader entities like communities, the public, and society. Frequently, however, students used general indications of “people” or “humans.” The most prevalent stakeholder group in this category was those people near the sites of e-waste recycling and/or disposal. Infrequently mentioned stakeholders in this category included farmers and affected people who were not part of the decision to recycle e-waste.
- The Government/NGO category included the governments of both industrialized and “developing” countries, as well as broader indications of these countries (perhaps as a superset including both their governments and the citizens they represent). The most prevalent stakeholder group in this category was “developing” countries. Infrequently mentioned stakeholders in this category included legislators, policy makers, non-governmental health organizations and regulatory groups.
- The Natural Environment category was comprised primarily of general indications of the environment, though some students also used the term ecosystem. Infrequently mentioned entities in this category included the Earth, air/water, rivers/lakes, flora and fauna.

Table 3 summarizes the above categories and shows the number of participants who indicated one or more stakeholders in each. All students in this sample indicated at least one stakeholder in the Technical/ Economic category in their responses to the third essay question. A strong majority indicated stakeholders in the Citizenry and Natural Environment categories; however, only about half of the students indicated stakeholders in the Governmental/ NGO category.

Table 4 summarizes the breadth of category coverage, showing how many participants indicated stakeholders in each number of categories. About half of the students mentioned stakeholders in all four of the above categories in response to the third essay question. About a third of the students mentioned stakeholders in three categories, and only a few mentioned stakeholders in two categories. No students indicated stakeholders in only a single category.

3.2. Responsibility (Descriptive Coding Results)

This section presents the preparatory findings regarding who engineering students associated with responsibility for the e-waste problem. Table 5 summarizes the passage-level findings, the codes for which were not mutually exclusive (i.e., multiple codes may have been applied to separate and/or overlapping passages in each essay).

Most participants were found to associate engineers with responsibility for the e-waste problem in some way. This was the expected outcome from the given prompt, which

implicitly presumed that there were “ethical responses” engineers might take, and students in this sample did not explicitly challenge the prompt. However, twenty-two participants also associated other entities and/or stakeholders with at least some of that responsibility.

Some responses were unclear in their association of engineers with responsibility and/or unclear even in their identification of engineers. For example, some of these passages did not explicitly mention engineers and could, at most, be considered as implying engineer responsibility due to references to “companies” and “manufacturers.” Given the context and the engineer-focused prompt, such responses seemed to implicate higher-level management or policy rather than “in the trenches” engineers and could be interpreted to indicate resistance to responsibility assumption (e.g., deflecting responsibility from engineers to others) and/or represent conceptions of engineers as lacking agency or power to act.

Finally, it is noteworthy that no participants in the present sample explicitly absolved engineers of responsibility for the e-waste problem. Such a response would have been surprising because it would directly challenge the assumption of engineer responsibility that is implicit in the essay question prompt. Nevertheless, we included this code primarily for the sake of completeness.

4. Findings (in Care Ethics Framework)

In this section, we tie the coding results from Section 3 back to the Responsibility element of the adopted care ethics framework (see Section 1.3), and then illustrate this with quotations from student writing.

It is helpful to ask at this point: what would “good responsibility” in care ethics look like in the e-waste recycling situation? For example, what approaches would engineers use and what attitudes would they have? How and why would they do what they decided to do? What would be their motivations? Whose needs and perspectives would be considered? Of course, this data set cannot speak to all of these questions because students were explicitly prompted only for what engineers should do, not the details of their approaches, attitudes, or motivations. Nevertheless, a careful reading of student responses in context reveals nuances that speak to some of these questions, especially those dealing with awareness of stakeholders and manners of assuming responsibility, both of which are explored further below.

4.1. Stakeholders (in Care Ethics Framework)

Given the magnitude and complexity of the e-waste problem, a number of stakeholders might be considered responsible because they have a direct influence on the situation. Adopting a care-ethical perspective helps spotlight stakeholders who are affected by the situation as well, such as the innocent people, flora, and fauna living near “backyard” e-waste recycling facilities who are being harmed by the resulting pollution. Clearly, many stakeholders are involved and will need to be involved in any realistic attempts to address the problem. Most of the students were aware of this (see Table 5). Nonetheless, we found variations in the degree to which student responses were likely to be effective in addressing the problem based on two possible measures of responsibility: (a) considerations of

multiple/varied stakeholders and (b) considerations of disadvantaged stakeholders (such as those who are vulnerable, powerless, or underprivileged) and their needs.

4.1.1. Multiple/Varied Stakeholders—A first order assessment of the sophistication of student thinking might be that the greater the number of relevant stakeholders considered, the more care-ethically responsible the response. Responses that indicated both influencing and affected stakeholders would be deemed more care-ethically responsible than those that mentioned stakeholders in only one direction of influence. Similarly, those responses that indicated non-engineer stakeholders (e.g., governments, communities, corporations) working with (or sometimes instead of) engineers would be more responsible than those that failed to mention non-engineering stakeholders at all. For example, Mason covered an extensive variety of non-engineering stakeholders when addressing the third essay question:

“Manufacturers of electronic devices have the ethical responsibility to produce low impact products and to offer to recycle outdated devices for consumers. However, manufacture[r]s listen to the consumer and since consumers desire the least expensive products, the most financially cost effective method of production is used. If consumer awareness rose then perhaps consumers would send manufacturers a different message. Some countries in Europe have already set standards for safe disposal of WEEE [waste electrical and electronic equipment]. For example, the EU [European Union] has a Directive to limit the chemicals that can be used in the recycling process called Restrictions on Hazardous Substances – RoHS. Developing countries are much farther behind in their regulations, especially in the enforcement thereof. Enforcement could come in many forms. A positive method would be for governments to give kickbacks to companies and consumers who choose to seek responsible recycling means. A negative method would be to monitor production of electronics, the recycling methods used and the disposal method of consumers.”

Mason’s response demonstrates some of the broad knowledge of key human stakeholders necessary to address the problem, and was one of the most prolific in terms of number of different stakeholder types indicated. His response is in sharp contrast to those essays that mentioned only a few human stakeholders, such as that of Chetan, who wrote:

“Engineers are partially accountable and should be employing design techniques which minimize waste. Certain electronic devices should be designed with quality components in order to maximize life and prolong replacement. [...] Providing consumers with long-lasting, reliable electronics will limit the opportunity for replacement.”

The examples from Mason and Chetan above suffice to illustrate the broad range in the number of stakeholders considered. Although all students in this sample mentioned stakeholders in two or more categories in their responses, many indicated stakeholders in all four categories (Table 4). This is encouraging from a care-ethical perspective, though there is clearly room for improvement, because nearly half the students did not consider key stakeholders in the government/NGO category (Table 3).

4.1.2. Disadvantaged Stakeholders—Some stakeholders influence the situation while others are only affected by it, some are in positions of greater vulnerability than others, and some have more power than others to make changes. When engineering students considered disadvantaged stakeholders (e.g., those who are vulnerable, powerless, and/or underprivileged), they were likely to be expressing more responsibility in a care-ethical sense than those who considered only powerful and privileged stakeholders. In the students' essays, we found a variety of disadvantaged stakeholder groups mentioned. Three of these groups—the working class, people near “backyard” recycling facilities, and future generations—are discussed herein. While other disadvantaged groups, including children, ecosystems, and the flora and fauna near sites of “backyard” e-waste recycling/disposal were mentioned by some students, these proved less useful in understanding perceived responsibility and are therefore not discussed in detail.

Several students expressed responsibility for disadvantaged stakeholders by considering the needs of the working class. For example, Shota associated engineers' responsibility with the job needs of “backyard” recycling facility workers:

“The goal for the engineers to solve an ethical issue is to satisfy all the stakeholders. Thus the goal for this issue is firstly to minimize the health problem, and secondly to maintain the existence of the facilities so that the workers will not lose their jobs.”

A counterexample of care-ethical responsibility for the working class appears in the writing of another student, Na, who wrote about designing for parts reuse and indicated manufacturing workers indirectly. However, in this case, her considerations were focused not on the needs of laborers, but on protecting the natural environment and improving economic efficiency for the manufacturing companies:

“[...] Thirdly, making the whole components of electrical or electronic equipments recycling [*sic*] [*recte* equipment recyclable] and can be used for [*sic*] many times. For example, one component in one [piece of] electrical equipment can be used in another [piece of] equipment. This will not only save the resources and protect the environment, but also be more economics [*sic*] and save labor force.”

In comparison with Shota's quote, which better demonstrated care-ethical responsibility for the working class, Na's quote serves to remind us that it is not enough just to mention relatively disadvantaged stakeholders: care-ethical responsibility also means considering their needs and perhaps giving a higher priority to those stakeholders who are disadvantaged in terms of vulnerability, power, or privilege. However, Na's quote also draws attention to another issue: that of prioritizing competing needs. For a given solution, how should the environmental impacts, economic benefits to manufacturers, and livelihood needs of employees be balanced and considered together?

Given that the provided reading and essay questions specifically called out the human health impacts of e-waste recycling in China and India, it comes as little surprise that many students mentioned the people living or working in and around “backyard” recycling facilities in their responses. For example, Carlos wrote:

“Overall it is clear that waste electronic recycling can greatly affect human life in areas contaminated by the byproducts of recycling. As engineers, it is important to consider how these problems can be solved.”

Jacob, in addition to the livelihood needs of the “backyard” recycling facility workers mentioned above, also wrote about the needs of people near recycling facilities, including farmers and other people affected by the resulting pollution:

“Farmers and communities will need to be relocated. The inhabitants of the affected communities will need to be examined and treated.”

It is perhaps the innocence of these people that makes them particularly vulnerable and disadvantaged. When showing responsibility in care ethics, we should not only include these stakeholders’ needs in our considerations, but should even prioritize them because of their vulnerability.

Finally, several students indicated a sense of responsibility for future generations. For example, Mason wrote:

“The ethical responsibility lies with all who participate in the use of electronic circuits to dispose of the old with foresight and respect for future generations.

Similarly, Putera wrote:

“For the future of our generations, the electronic industry needs to be re-evaluated.”

Compared to innocent populations adjacent to hazardous e-waste recycling facilities, future generations are perhaps even more disadvantaged by virtue of their complete lack of power to influence the present situation.

These examples of disadvantaged stakeholders mentioned by many of these engineering students in their essays are encouraging. However, some students in this sample did not indicate disadvantaged stakeholders other than the natural environment in response to the third essay question. While such absence could potentially be due to the terse and direct writing styles of some engineers, it could also suggest an attempt to disassociate the “real,” technical engineering work from what they perceive to be merely contextual factors that are beyond the purview of engineering (cf. content knowledge and the engineering problem-solving method in Leydens and Lucena 2007).

4.2. Engineers’ Responsibility (in Care Ethics Framework)

In this section, we look at the ways in which engineering students acknowledged (or neglected to acknowledge) the responsibility of engineers for the e-waste recycling problem. While most students acknowledged engineers’ responsibility for the e-waste problem (Table 5), the degree to which they did so varied and is described in more detail in Table 6. Over half of the students associated both engineers and non-engineers with (shared) responsibility for the problem. This suggests that most students held realistic views of the situation and recognized, to varying degrees, the complexity of the problem. In contrast, four essays were everywhere ambiguous with respect to engineers’ responsibility for the e-waste problem. This ambiguity was due either to a lack of clarity in identifying stakeholders (e.g., using the

words “companies” or “manufacturers” to imply engineers) or to neglecting to mention or even imply engineers in their responses thereby associating only others (non-engineers) with responsibility. Each of the four different manners in which students acknowledged the responsibility of engineers in Table 6 is described in detail below.

4.2.1. Responsibility: Without Qualification/Limitation—Seven student essays explicitly acknowledged the responsibility of engineers without any qualifications, limitations, or association of other stakeholders with responsibility. Some expressed very firm conviction, such as the following declaration by Jeremy:

“Engineers, above all else, are accountable for proper collection, recycling and disposal of WEEE [waste electrical and electronic equipment]. Therefore, they must take a responsible and a[n] integrated approach to this issue.”

Others were perhaps less imperative, but still clearly indicated that engineers held responsibility, such as Feng, who wrote:

“I think modern engineers producing these electronic technologies should turn their eyes to the environmental impact that dumping the electronic waste has brought about. They should pay more attention to the environment and realize the significance of environmental protection.”

While the association of only engineers with responsibility could indicate a somewhat naïve and simplistic view of the situation (e.g., as if engineers alone could solve such a complex problem), note that the prompt asked specifically for ethical responses of engineers producing electronic technologies. Some students may thus have chosen to limit the scope of their responses to that of engineers’ responsibility and intentionally excluded consideration of other responsible stakeholders and entities.⁹

4.2.2. Responsibility: Shared with Others—Ten of the student’s essays acknowledged the responsibility of engineers without any qualifications or limitations while also pointing out that this responsibility was shared with other stakeholders. Several of these essays included notions that “everyone” was responsible and then went on to specify stakeholder groups, such as consumers, distributors, manufacturers, and design engineers. For example, Sophia implicated everyone involved in the creation and use of electronics when she wrote:

“When faced with such a problem as the quality of human life, it is easy to point the finger and say “they didn’t do enough” or “they should be held accountable”, but in reality it is the responsibility of everyone involved: this is everyone from the engineers who designed the electronic, to the producers, to the sellers, to the consumers and everyone in between.”

Several essays were less broad in attributing responsibility to others, indicating a few specific stakeholder groups, such as electronics companies or governments. For example,

⁹As a case in point, Sophia explicitly indicated that she did this when she wrote: “Though it is possible to speak about the “ethical” responsibilities of everyone involved, this paper will focus its attention on the efforts of engineers, the masterminds and first line of responsibility in the creation and distribution of these electronics.”

Santiago associated the people/governments of technologically advanced countries, electronics manufacturers, and engineers with responsibility when he wrote:

“[...] countries that are able to produce highly technical electronic devices should be held accountable to the waste that is created from the product. Technology is rapidly increasing and due to this rapid increase, there is more of a build-up in hazardous waste. I think that manufacturing companies should hold more responsibility to how their products are being recycled. [...] As a future engineer, I think that we should be more responsible with how the product we engineer is created and how we should take into account the best procedure to properly recycle it.”

There were two essays that associated non-governmental organizations (NGOs) with responsibility. For instance, Arnav implicated health organizations in this quote:

“It is vital for engineers and health organizations to attend to this situation and dedicate sufficient resources to help solve this persistent situation.”

These students understood that e-waste was not the responsibility of engineers alone, but instead required a shared responsibility to engage in productive solutions to this global problem.

4.2.3. Responsibility: Shared with Others but Qualified/Limited—Nine of the student’s essays acknowledged engineers’ responsibility as shared with other stakeholders, but placed limitations, constraints, or qualifications of some kind on engineers’ responsibility. Five of these essays indicated that engineers’ responsibilities for the problem were contingent upon other factors, such as governmental regulations, support from employers, and/or economic constraints. For example, Wyatt felt that product-design related changes like using biodegradable materials was “about as far as” electronics engineers can go, but that this could help legislators enact better e-waste disposal regulations:

“The above steps in making a device as easy as possible to recycle is about as far as the engineers designing the[m] will be able to go to facilitate the device’s ultimate responsible disposal. However, by making the entirety of the device more economical to recycle, the engineers making these decisions may help legislators establish more stringent and effective environmental controls governing the disposal of e-waste.”

Other essays expressed expanded or diffused notions of responsibility that took the focus off of engineers to varying degrees. For example, Lizzie wrote of the engineers’ responsibility as an extension of corporate responsibility:

“I believe that engineers can help solve some of the issues with electronic waste. As the people who are designing products that are being consumed at high volume, it is the company who produces the products, and by extension, the engineer’s duty to observe and adjust design to avoid negative consequences of their work.”

A more extreme case of diffusion appeared in the essay of Chloe, who associated both engineers and non-engineers with responsibility for the e-waste problem, but neglected to

provide any indications of ways in which engineers might exercise their responsibility. Her initial statement that engineers are directly responsible seemed straightforward:

“The engineers producing these hard-to-dispose-of electronic materials should have full accountability for the effect the materials have on the environment. If the engineers were not designing these materials, disposal would not be an issue.”

However, Chloe goes on to deflect responsibility away from engineers, assigning it instead to the companies for whom they presumably work:

“That being said, the companies responsible for producing these materials should be held fully accountable for the impact of their products. When it is discovered that a company’s products are, in effect, destroying an ecosystem, the company must be required to first, either change the manufacturing process of their products that results in such devastating consequences and/or be required to implement a recycling system that all potential customers have access to, so products do not get disposed of in ways that would be harmful to the ecosystem. If no manufacturing changes can be implemented and a recycling system cannot be found, the company should not be allowed to continue making their products [...]”

Other than what might be implied by the above statement for engineers to actually do (i.e., change manufacturing processes and/or implement recycling systems), engineers’ avenues for assuming responsibility appears to be limited or constrained by the decisions of the companies for whom they work. This might indicate resistance to assuming responsibility, a position apparently taken by some students in this study as illustrated below.

4.2.4. Responsibility: Ambiguous or Absent—Four essays were ambiguous with respect to the responsibility of engineers for the e-waste problem because the word engineer did not appear anywhere in the essay. Some of these essays contained only references to the “companies” and “manufacturers” for whom engineers presumably work, and some of these essays did not even imply engineers through use of the word design. These essays may indicate resistance to responsibility (e.g., deflecting responsibility from engineers to others) and/or conceptions of engineers as lacking agency or power to act. For example, Olivia suggested that everyone, namely companies, governments, and customers, should do their part, but nowhere identifies engineers as responsible:

“As the electronics world continues to prosper and grow, the need for safer recycling practices is becoming more immanent. Companies rarely take into consideration what happens to their products in the longer term. Harmful toxins are released into the atmosphere and are harming human and environmental health as a result of bad recycling practices. As time goes on and the electronics market continues to grow, companies, governments and customers must strive to reduce the harsh toll that waste electronics recycling has. There are safe ways to dispose of electronics and everyone must do their part to practice these better techniques.”

Surprisingly, Isabella felt that responsibility lies with the people who are actually recycling the waste since they are choosing to harm themselves and their own environment:

“It is up to the people living in the area how they want to go about recycling their electronic wastes so that it has minimal ethical implications on themselves and their environment alike.”

Like Isabella, Jacob also did not appear to see a relationship between the engineers designing and manufacturing electronic equipment and the eventual disposal/recycling of this equipment by others. For him, the problem was largely a matter of governmental regulation and control:

“To resolve the issue, more oversight is necessary. First of all, the illicit dumping needs to be policed, especially along major rivers and lakes. Finding and shutting down illicit recycling centers should be a priority in the short term. If agencies are able to shut down the existing sources of pollution, it will halt dumping [...] Governmental agencies should not only halt illicit dumping, but develop a long term solution to repair local ecosystems and communities, monitor the safety of food supplies, and construct facilities with strong oversight that will properly recycle electronic waste.”

Thus, what we saw when students neglected to mention engineers, seemingly absolving them of responsibility for the global e-waste problem, was not a single position or reason why. Instead, students in this category had a variety of reasons for reducing or eliminating the engineer’s responsibility.

5. Synthesis and Implications

In this section, we synthesize our findings and explore possible implications, including suggestions for future work.

5.1. Synthesis of Findings

Given the relatively small size of our sample and the interpretive nature of the work, this brief synthesis of the findings is best viewed as *moderatum* generalizations (Williams 2000; Payne and Williams 2005), in which both the scope of the claims and the degree to which they are held are appropriately moderate. Because the paper uses empirical findings to scaffold conceptual exploration, the nature of *moderatum* generalizations that can be reasonably drawn will also vary. Specific comments on the limitations of the empirical findings are described in the last paragraph of this sub-section.

The coding results indicated that nearly all students in our intentional sample of 30 essays considered stakeholder groups that we categorized as technical/economic, environmental, and citizenry, but only about half the students mentioned governmental or non-governmental organizations (Table 3). Looking at these findings through a care-ethics lens (Section 4.1), we identified two possible measures of care-ethical responsibility as indications of the relative quality of responses: multiplicity/variety of indicated stakeholders, and consideration of disadvantaged stakeholders and their needs. Multiplicity/variety of stakeholders is an aspect of care-ethical responsibility that provides ties back to Attentiveness in Tronto’s care ethics framework and increases the chances that disadvantaged (e.g., vulnerable, powerless, and/or underprivileged) stakeholders will have

their voices heard and their needs met. Even more generally, human stakeholder awareness could be considered a first step towards broader awareness of the direction of a stakeholder's influence (i.e., influencing and affected) that includes not only human stakeholders but also environmental/ecological entities that may be involved. Note, however, that the sheer number of different stakeholders considered does not necessarily make a given response more care-ethically responsible than another: it simply increases the likelihood that this will be the case. It is possible to consider many stakeholders, but miss those who are in most need of consideration. Thus, the best (i.e., most care-ethically responsible) responses will also draw appropriate attention to specific stakeholders (and their needs) who are in some way disadvantaged compared to other stakeholders.

Coding also revealed that most (though not all) of these engineers of tomorrow associated engineers with responsibility for the e-waste problem (Table 5) in some way (Table 6). Furthermore, in spite of being asked specifically about the responsibilities of engineers for the e-waste recycling problem, many participants associated other entities and/or stakeholders with at least some of that responsibility. Looking at these findings through a care-ethics lens (Section 4.2), we identified a third possible measure of care-ethical responsibility: manner of acknowledging responsibility. Here we examined variations in the ways in which students acknowledged engineers' responsibility and categorized them as: (a) acknowledging (possibly sole and complete) responsibility for the problem, (b) sharing responsibility with other stakeholders, and (c) acknowledging limited responsibility for the problem.

At first glance, the notion of sharing responsibility with others might seem to strike an Aristotelian "golden mean" between the extremes of over-committing and diffusing or deflecting responsibility; however, even within each of these extremes, one can find both good and bad facets of care-ethical responsibility that are informative. For example, while the mindset of unreservedly acknowledging one's responsibility could be a sign of naivety leading to unworkable solutions, it may also evince a positive willingness to help (in spite of not really knowing how to do so) that is more likely to contribute creative ideas through its optimistic "find-a-way," "can-do" attitude. Alternatively, while the mindset of placing limitations on the scope of one's responsibility could be conservative or evasive, it may also reveal a sense of realistic awareness of one's own power for action (and its limitations or constraints) that would encourage collaboration with others who are in better positions to help. In other words, this shows the following attributes of responses that are more (and less) care-ethically responsible: (a) they are motivated by positive willingness to help (rather than defensive "that's not my job" attitudes), (b) they involve sharing responsibility in ways that encourage openness and collaboration (rather than either setting arbitrary boundaries or trying to do everything oneself), and (c) they incorporate mature awareness of limitations and constraints, and of the abilities and capacities of oneself and others (rather than taking an unreflective approach that ignores these considerations).

We also observe that these three measures of care-ethical responsibility (i.e., multiplicity/variety of stakeholders, consideration of disadvantaged stakeholders, and manner of acknowledging responsibility) provide ties forward to the third element of Tronto's framework, Competence (see Fig. 1), impacting the likelihood of good "care-giving." In

other words, the act of assuming care-ethical responsibility can be viewed as a form of planning (i.e., “this is what I’m going to do, and this is how I’m going to do it”), which is suggestive of the potential or promise for care-ethical competence. Deficiencies in such planning would lead to ineffective actions and unpromising solutions. While it is beyond the scope of this empirically-based article to attempt a comprehensive philosophical treatise on the topic, we provided this brief synthesis as a first step toward better understanding care-ethical responsibility in the context of engineering and the problem of e-waste recycling/disposal.

Before moving into the study’s implications, a brief note on limitations of the empirical findings are in order. First, recall that this study examined a relatively small, intentional sample of student responses to the e-waste recycling problem. This sample was chosen to maximize the demographic diversity in the available data to reveal perspectives from a broader set of backgrounds, cultures, and life experiences, thus diversifying the findings compared to trends obtained from purely random sampling. Note also that the analysis sought to cover the breadth of responses rather than to reveal statistically significant trends because the purpose of the study was descriptive and exploratory. Any interpretations of the findings with respect to trends and prevalence must be made judiciously. If widely generalizable results are sought, the findings from this work can be used to inform the larger, quantitative or mixed-methods studies that would be needed to achieve the statistical power and confidence necessary for broader generalizations. The present work provides useful constructs, ideas, and suggestions to inform such future work. Also note that the essay prompt implied engineer responsibility (rather than freely soliciting for a list of responsible entities) and that ascriptions of responsibility to non-engineers were not the primary focus of this analysis. Finally, note that the assignment used to generate the data was not created with Tronto’s care ethics framework explicitly in mind and we relied on a broad, intuitive understanding of care ethics and social justice (though ideas of humanitarianism and engineering ethics were explicit in our thinking at the time). Nevertheless, the elements of Tronto’s framework have proven useful for interpreting and assessing the resulting student work, and thereby supporting conceptual explorations of care ethics in this context.

5.2. Implications

In this sub-section, we explore some of the implications for engineering education (including practical suggestions that apply to a variety of learning environments), empirical educational research (especially future work), and engineering ethics including suggestions for educational policy and the practice of engineering.

Implications for Teaching and Learning Engineering—Engineering education has traditionally focused on technical problems and their solutions, and topics of ethics have typically received little attention in most engineering classrooms and programs. Even in courses dedicated to engineering ethics, human values explicitly tied to care and concern for the well-being of others are seldom discussed, and the focus tends to be on more abstract issues of rights, duties, fairness, and utilitarian principles (e.g., the greatest good for the greatest number of people). This paper has demonstrated the application of an ethical framework (care ethics) that deals specifically with care and concern for others. We view

this as a missing dimension to engineering education broadly, and to engineering ethics education in particular. By demonstrating the value and applicability of care-ethical responsibility for exploring ethical practices in engineering, this work suggests new avenues for coursework and assignments that can expose students to additional considerations of the ethical impact of engineering work beyond those most commonly discussed (e.g., duties, rights, utility).

In the present work, unintended consequences of e-waste in industrializing regions were highlighted. Other topics that have humanitarian or social justice themes could also be explored through a care ethics lens (e.g., see Campbell, Yasuhara, and Wilson 2015). E-waste and other topics could be covered in courses dedicated to engineering ethics using a variety of ethical frameworks in addition to care ethics (i.e., a pluralistic approach). Alternatively, a care ethics framework could be introduced in programs that use an “ethics across the curriculum” approach to examine a variety of topics and contexts that would benefit from care-ethical considerations.

Humanitarian Engineering courses and programs can also benefit from this work because such programs are premised on the idea of engineers in a “care-giving” role helping others address their needs. Care ethics and the notion of Responsibility are important considerations to reflect upon when engaging in activities like those performed in service learning programs or by groups like Engineers Without Borders (EWB) and Engineers for a Sustainable World (ESW).

A practical way to use this work in any of the above-mentioned courses and programs is to create assessment rubrics based on care-ethical considerations. Such rubrics could be used formatively by students for self-assessment or peer-assessment, or by instructors for grading projects or evaluating student approaches to design. Based on the findings in this paper, we suggest the following measures of care-ethical responsibility: (a) multiplicity and variety of indicated stakeholders (e.g., simple counts, variety of different stakeholders, or indications of direction of influence), (b) explicit consideration of disadvantaged stakeholders (e.g., those who are vulnerable, powerless, underprivileged), and (c) indications of appropriate, collaborative responsibility (e.g., that avoid the two extremes of over-committing and diffusing/deflecting responsibility).

Implications for Empirical Educational Research—One idea for future work is to look for patterns across demographics. For example, one might hypothesize that women would bring a different set of considerations to the e-waste problem than men (e.g., see Kilgore et al. 2007b, 2007a), or that non-native speakers of English would understand and/or express responsibility in different ways (which would require additional research methods, such as interviews or focus groups, for meaningful analysis).

Another potential topic of future work was identified in Section 4.2.4 with the ideas of agency and power to act, or in other words, what engineers think they are capable of and allowed by their profession or employers to do. As an aspect of care-ethical responsibility, an engineer’s sense of agency will influence the kinds of things they will attempt and the people and organizations with whom they will think to collaborate. In Sections 3.2 and 4.2,

we looked at responsibility assumption (i.e., who was thought to be responsible for the e-waste recycling problem). Future work might look at how or the ways in which engineers are said to be responsible for the e-waste problem (i.e., what actions are suggested for engineers to take), or it might examine the ways engineers interact with others when assuming responsibility for the problem. Both of these ideas would support further exploration of responsibility assumption, agency, and awareness of power (and its limitations/constraints). In terms of Tronto's framework, notions of interacting with others also feed forward to care-ethical competence in that neglecting to work with non-engineers in addressing such a complex problem as that of e-waste would surely doom any potential solutions to failure. Thus, the sequence of "who, how, ways of interacting" creates a bridge from care-ethical responsibility toward care-ethical competence, providing a predictive measure¹⁰ of the promise or likelihood of Competence. Future work might explore this bridge, as well as find ways to assess Competence directly by studying design artifacts, design processes, or even the extra-/co-curricular activities of engineering students once they become aware of a problem and decide to do something to address it. Finally, future work might involve designing research studies to explore care-ethical thinking more broadly, for example, by expanding coverage of Tronto's care-ethics framework to include the other elements, like Attentiveness, Responsiveness, and Integrity. The engineering community would likely benefit from a deeper understanding of each of these elements, both separately and holistically.

Implications for Engineering Ethics—Understanding the ethical implications of this work requires some additional discussion of care ethics. In this sub-section we lay out some care-ethical terms and concepts that help us shed light on the implications of the work for engineering ethics.

One ethical implication we highlight is the need to raise awareness of the e-waste recycling problem. This was even pointed out by two participants, including Diego, who wrote "First and foremost is an engineer realizing that recycling of electronic waste affects everyone." Using a language of care, we could say that the most salient needs in this scenario are those of human and environmental health in and around "backyard" e-waste recycling operations. We could also identify the "care-receivers" as the people and ecosystems near those facilities, and the "care-givers" as the modern engineers creating the electronic technologies that are eventually being recycled in harmful ways.

Use of the word "care-giver" here may cause some readers to pause: in ordinary usage of the term, the work that care-givers perform usually requires direct interaction with care-receivers (such as in the doctor/patient relationship) but in the e-waste scenario, practical constraints of time and distance would prevent most electronics design engineers from ever interacting directly with the aforementioned care-receivers. Given the large proximal, temporal, and even causal distances between the two, it may be challenging to make the mental link between a circuit-board design engineer in an air-conditioned North American office and a villager 10 years later in India extracting heavy metals using the family cooking

¹⁰Though such a predictive measure would be most appropriately used for formative educational purposes or research, rather than for summative evaluation.

pan.¹¹ Nevertheless, for engineers to respond ethically as “care-givers” (i.e., by either addressing the aforementioned needs, or avoiding creating such needs in the first place) requires that they be aware of their involvement in this relationship, however distant it may be. Unfortunately, this relationship is nebulous for most engineers, as the problem is largely unknown and invisible to them. Greater awareness is needed both within technical contexts and without to reach more engineers, their managers and the companies they work for, as well as consumers and policy makers who need to be more aware of and responsible for the consequences of their decisions. As Pickren (2014) shows, institutions and NGO’s can serve to mediate the abilities of individuals and groups to ‘care at a distance’ and to make global connections more sustainable and ethical in the area of e-waste recycling and disposal.¹² Future work should explore such literature for effective ways that engineers can improve the situation, and we as engineers, educators, and scholars should do what we can to help raise awareness of the problem in broader circles.

Another implication for ethics, one that involves rethinking the way engineering is practiced, emerges from a deeper understanding of care ethics. Tronto (1993, p. 114) pointed out that the way the duties of care are typically assigned in many western cultures has important implications. Her first two phases of care—“caring about” and “taking care of,” corresponding to Attentiveness and Responsibility, respectively—tend to be the duties of people with more prestige and power (e.g., doctors, policy makers, and administrators). Her last two phases of care—“care-giving” and “care-receiving,” corresponding to Competence and Responsiveness, respectively—tend to be the duties of people with less prestige and power (e.g., nurses, social workers, and janitors). This split in roles is often done in the service of efficiency: doctors examine patients and decide what to do, and then delegate to nurses, orderlies, and lab technicians so that the doctor can move on and use their expertise to help more patients. While the practical aspects of such delegations are perhaps difficult to contest, the quality and effectiveness of care can easily suffer in these situations, such as when communication within the care team is poor, or when the work is performed too quickly or without the necessary sensitivity to notice what is helping and what is not.

In the context of e-waste recycling, this imbalance of power holds true as well: it is the relatively powerful engineers of the industrialized world who are in positions to be primarily Attentive and Responsible. The forms of “care-giving” (Competence) they can perform are usually so far removed in time and distance that the Responsiveness phase becomes difficult if not impossible. This points to the importance of somehow closing the feedback loop so that the relatively powerful engineers can understand the importance of the needs they may be creating and assess whether or not their actions are having desirable outcomes. In other words, they must somehow improve the Integrity of their care by better aligning their Attentiveness, Responsibility, Competence, and Responsiveness with the needs of the people and ecosystems they are inadvertently impacting. The implication for engineering ethics suggested here is for engineers (as well as companies and even society) to rethink the roles and approaches to engineering that we currently employ. Is it ethical to continue the

¹¹Unfortunately, this may be a common practice – see <http://ngm.nationalgeographic.com/2008/01/high-tech-trash/essick-photography> (retrieved March 23, 2016).

¹²Thanks to an anonymous reviewer for suggesting this connection to a related body of literature.

“business as usual” approach to electronics design now that we know some of the harm and damage it can cause?

Humanitarian engineering programs have the potential to improve this disconnect in the caring roles by taking more holistic and contextual approaches to engineering; however, the danger of paternalistic patterns of engagement are potentially high (see Vandersteen, Baillie, and Hall 2009; Campbell, Yasuhara, and Wilson 2015; and the idea of “less-than” in Schneider, Lucena, and Leydens 2009). Other approaches that involve changing the power relationships may also help, and engineering ethicists would be in good positions to suggest and advocate for alternatives. If nothing is done, we risk committing an ethical failing that Tronto terms “privileged irresponsibility” (1993, pp. 120–122, 146). Privileged irresponsibility is a “consequence of the unbalanced nature of caring roles and duties in our culture” by which the relatively privileged remain unaware of others’ difficulties that they do not themselves face. She gives the example of racism and “white skin privilege”¹³ in the United States. A similar problem seems to exist between industrialized and industrializing countries (and even within them) with regard to electronic devices and their eventual recycling and disposal: out of sight, out of mind. We believe the field of engineering ethics has a responsibility (care-ethical or otherwise) to help change the situation and create a more caring and socially just engineering profession.

6. Conclusions

In this paper, we explored the concept of responsibility empirically using an ethical framework that is seldom applied in engineering contexts: ethics of care. Specifically, we grounded conceptual explorations of engineering responsibility in empirical findings from engineering student writing on the human health and environmental impacts of “backyard” electronic waste recycling/disposal in industrializing countries. The research was guided by the question of how students exhibit care-ethical responsibility in the context of “backyard” e-waste recycling and what the associated implications might be (e.g., on teaching and learning engineering and engineering ethics). Our analysis looked at essays from a purposefully diverse sample of engineering students in an introductory electrical engineering course in the western United States. Students were asked, among other things, to respond to the question of what modern engineers producing electronic technologies should do as an “ethical” response to the problem of “backyard” e-waste recycling. We performed two levels of analysis on these responses: the first was a descriptive coding that provided a foundation for the second, more interpretive layer.

In the first level of analysis, we looked at the stakeholders that students indicated and at whom they associated with responsibility for the e-waste recycling problem. In the second level of analysis, we adopted a framework for care ethics from the wider literature and used the empirical data to facilitate a preliminary, conceptual exploration of care-ethical

¹³White skin privilege is part of the implicit social system of racism that provides opportunities to some people, but not others, based on the color of their skin (Tronto 1993, p. 121). Unfortunately, those who benefit from this system need neither recognize their privilege, nor feel any responsibility for racism’s continued existence because they do not think they have a prejudice. Therefore, those in the dominant group, who have the most power to change the system, see no reason to do so. They need not even deliberately refuse to assume responsibility for the problem because they simply do not see it, and therefore, the difficulties experienced by minority groups persist.

responsibility within the context of engineering and the global e-waste recycling/disposal problem. Specifically, we examined three possible measures of care-ethical responsibility: (1) multiplicity/variety of indicated stakeholders, (2) consideration of disadvantaged (e.g., vulnerable, powerless, or underprivileged) stakeholders, and (3) manner of acknowledging engineers' responsibility. This exploration provided a first step toward understanding how care-ethical responsibility manifests in engineering, and was intended to seed dialogue within the engineering community about its responsibilities (care-ethical or otherwise) on the issue of global e-waste, with implications for engineering education and engineering ethics that suggest changes for educational policy and the practice of engineering.

This article demonstrated an unconventional approach to exploring engineering ethics in a number of respects. First, it adopted an ethical framework (care ethics) that has not received much attention in the engineering field. It also employed an empirically-based approach to exploring engineering ethics, which both facilitated a deeper understanding of the ethical responsibilities of engineers and provided a baseline for understanding the ethical thinking of engineering students, who are the next generation of engineers. Furthermore, the context-dependent nature of the work¹⁴ served to focus the analysis thereby producing practical implications for education (see Implications for Teaching and Learning Engineering in Section 5.2 above). We hope these aspects of our work also contribute to the field of engineering ethics and to improving the education of engineers.

Acknowledgments

The authors wish to express their sincere gratitude to Dr. Ken Yasuhara at the University of Washington Center for Engineering Learning & Teaching (CELT) for his invaluable feedback and encouragement throughout the development of this manuscript.

This material is based upon work supported by the National Science Foundation under Grant No. 0909817. Partial support for this research came from a *Eunice Kennedy Shriver* National Institute of Child Health and Human Development research infrastructure grant, R24 HD042828, to the Center for Studies in Demography & Ecology at the University of Washington.

References

- Allendoerfer C, Wilson D, Bates R, Crawford J, Jones D, Floyd-Smith T, Plett M, Scott E, Veilleux N. Strategic pathways for success: The influence of outside community on academic engagement. *Journal of Engineering Education*. 2012; 101(3):512–538. <http://doi.org/10.1002/j.2168-9830.2012.tb00060.x>.
- de la Bellacasa MP. Matters of care in technoscience: Assembling neglected things. *Social Studies of Science*. 2011; 41(1):85–106. <http://doi.org/10.1177/0306312710380301>. [PubMed: 21553641]
- Campbell, RC. How can engineering students learn to care? How can engineering faculty teach to care?. In: Lucena, J., editor. *Engineering Education for Social Justice: Critical Explorations and Opportunities*. Vol. 10. Dordrecht, Netherlands: Springer; 2013. p. 111-131. http://doi.org/10.1007/978-94-007-6350-0_6
- Campbell, RC., Yasuhara, K., Wilson, D. Care ethics in engineering education: Undergraduate student perceptions of responsibility. *Proceeding of the 42nd Annual Frontiers in Education (FIE)*

¹⁴The context-dependent nature of the work is consistent with the care-ethical framework we adopted, which recognizes that the “right thing to do” is dependent on situational factors including the specific actors involved. Theorists looking for universal or widely generalizable claims might view this as a limitation, but if so, they may be missing some important dimensions of care ethics, namely, its practicality and the challenge it poses to abstract, universalistic approaches to ethics (see Held 2007).

- Conference; Seattle, WA, USA: Institute of Electrical and Electronics Engineers (IEEE), Inc; 2012. p. 1-6.<http://doi.org/10.1109/FIE.2012.6462370>
- Campbell, RC., Yasuhara, K., Wilson, D. Ethics in engineering students' design considerations: Case studies of electric power systems for the "developing world". Proceedings of the American Society for Engineering Education (ASEE) Annual Conference; Seattle, WA, USA: American Society for Engineering Education; 2015. p. 1-18.<http://doi.org/10.18260/p.24024>
- Carnegie Foundation. The Carnegie classification of institutions of higher education. 2010. Retrieved March 23, 2016 from: <http://carnegieclassifications.iu.edu/>
- Eshleman, A. Zalta, EN., editor. Moral responsibility. The Stanford Encyclopedia of Philosophy. 2014 Summer. Retrieved March 23, 2016 from <http://plato.stanford.edu/archives/sum2014/entries/moral-responsibility/>
- Fischer, JM., Ravizza, M. Responsibility and control: a theory of moral responsibility. Cambridge; New York: Cambridge University Press; 1998.
- Frankfurt HG. Alternate possibilities and moral responsibility. The Journal of Philosophy. 1969; 66(23):829–839. <http://doi.org/10.2307/2023833>.
- Franssen, M., Lokhorst, GJ., van de Poel, I. Zalta, EN., editor. Philosophy of Technology. The Stanford Encyclopedia of Philosophy. 2013 Winter. Retrieved March 23, 2016 from <http://plato.stanford.edu/archives/win2013/entries/technology/>
- Friedman B. Value-sensitive design. Interactions. 1996; 3(6):16–23. <http://doi.org/10.1145/242485.242493>.
- Gilligan, C. In a different voice: Psychological theory and women's development. Cambridge, Massachusetts, USA: Harvard University Press; 1982.
- Gilligan, C. Moral orientation and moral development. In: Held, V., editor. Justice and care: Essential readings in feminist ethics. Boulder, CO, USA: Westview Press Inc; 1995. p. 31-46.
- Hamington, M., Sander-Staudt, M., editors. Applying Care Ethics to Business. Vol. 34. Dordrecht, Netherlands: Springer; 2011.
- Held, V. The ethics of care: Personal, political, and global. New York, NY, USA: Oxford University Press; 2006.
- Held, V. The ethics of care. In: Copp, D., editor. The Oxford handbook of ethical theory. Oxford, England: Oxford University Press; 2007. p. 537-567. Retrieved March 23, 2016 from <http://www.oxfordhandbooks.com/view/10.1093/oxfordhb/9780195325911.001.0001/oxfordhb-9780195325911-e-20>
- Kardon JB. Concept of "care" in engineering. Journal of Performance of Constructed Facilities. 2005; 19(3):256–260. [http://doi.org/10.1061/\(ASCE\)0887-3828\(2005\)19:3\(256\)](http://doi.org/10.1061/(ASCE)0887-3828(2005)19:3(256)).
- Kilgore D, Atman CJ, Yasuhara K, Barker TJ, Morozov A. Considering context: A study of first-year engineering students. Journal of Engineering Education. 2007a; 96(4):321–334. <http://doi.org/10.1002/j.2168-9830.2007.tb00942.x>.
- Kilgore, D., Chachra, D., Loshbaugh, H., McCain, J., Jones, M., Yasuhara, K. Creative, contextual, and engaged: Are women the engineers of 2020?. Proceedings of the American Society for Engineering Education (ASEE) Annual Conference; Honolulu, HI, USA: American Society for Engineering Education; 2007b. <https://peer.asee.org/2324>
- Kittay, EF. Love's labor: Essays on women, equality and dependency. New York, NY, USA: Routledge; 1999.
- Latour, B. Where are the missing masses? The sociology of a few mundane artifacts. In: Bijker, WE., Law, J., editors. Shaping technology / building society: Studies in sociotechnical change. Cambridge, MA, USA: The MIT Press; 1992. p. 225-258. Retrieved March 23, 2016 from <http://www.bruno-latour.fr/node/258>
- Leydens, JA., Lucena, JC. The problem of knowledge in incorporating humanitarian ethics in engineering education: Barriers and opportunities. Proceeding of the Frontiers in Education (FIE) Conference; Milwaukee, WI, USA: Institute of Electrical and Electronics Engineers (IEEE), Inc; 2007. p. 24-29.<http://doi.org/10.1109/FIE.2006.322645>
- Noddings, N. Caring: A feminine approach to ethics and moral education. 2. Berkeley, CA, USA: University of California Press; 2003. (Original work published 1984)

- Pantazidou M, Nair I. Ethic of care: Guiding principles for engineering teaching and practice. *Journal of Engineering Education*. 1999; 88(2):205–212. <http://doi.org/10.1002/j.2168-9830.1999.tb00436.x>.
- Payne G, Williams M. Generalization in Qualitative Research. *Sociology*. 2005; 39(2):295–314. <http://doi.org/10.1177/0038038505050540>.
- Pesch U. Engineers and Active Responsibility. *Science and Engineering Ethics*. 2015; 21(4):925–939. <http://doi.org/10.1007/s11948-014-9571-7>. [PubMed: 25005341]
- Pickren G. Political Ecologies of Electronic Waste: Uncertainty and Legitimacy in the Governance of E-Waste Geographies. *Environment and Planning A*. 2014; 46(1):26–45. <http://doi.org/10.1068/a45728>.
- Riley D. Hidden in plain view: Feminists doing engineering ethics, engineers doing feminist ethics. *Science and Engineering Ethics*. 2013; 19(1):189–206. <http://doi.org/10.1007/s11948-011-9320-0>. [PubMed: 22033855]
- Roeser S. Emotional engineers: Toward morally responsible design. *Science and Engineering Ethics*. 2012; 18(1):103–115. <http://doi.org/10.1007/s11948-010-9236-0>. [PubMed: 20936371]
- Schneider J, Lucena J, Leydens JA. Engineering to help. *IEEE Technology and Society Magazine*. 2009; 28(4):42–48. <http://doi.org/10.1109/MTS.2009.935008>.
- Sepúlveda A, Schluep M, Renaud FG, Streicher M, Kuehr R, Hagelucken C, Gerecke AC. A review of the environmental fate and effects of hazardous substances released from electrical and electronic equipments during recycling: Examples from China and India. *Environmental Impact Assessment Review*. 2010; 20:28–41. <http://doi.org/10.1016/j.eiar.2009.04.001>.
- Sunderland ME. Taking emotion seriously: Meeting students where they are. *Science and Engineering Ethics*. 2014; 20(1):183–195. <http://doi.org/10.1007/s11948-012-9427-y>. [PubMed: 23307623]
- Tronto, JC. *Moral boundaries: A political argument for an ethic of care*. London, Great Britain: Routledge; 1993.
- Tronto, JC. *Caring democracy: Markets, equality, and justice*. New York, NY, USA: New York University Press; 2013.
- Vandersteen J, Baillie C, Hall K. International humanitarian engineering. *IEEE Technology and Society Magazine*. 2009; 28(4):32–41. <http://doi.org/10.1109/MTS.2009.934998>.
- Williams M. Interpretivism and generalisation. *Sociology*. 2000; 34(2):209–224. <http://doi.org/10.1177/S0038038500000146>.
- Wilson, D., Allendoerfer, C., Campbell, RC., Burpee, E., Kim, MJ. When engineering students write about waste electronics: Trends in how they think of global impacts. *Proceedings of the American Society for Engineering Education (ASEE) Annual Conference*; Atlanta, GA, USA: American Society for Engineering Education; 2013. p. 1-17. <https://peer.asee.org/22754>
- Van Wynsberghe A. Designing robots for care: Care centered value-sensitive design. *Science and Engineering Ethics*. 2013; 19(2):407–433. <http://doi.org/10.1007/s11948-011-9343-6>. [PubMed: 22212357]

Fig. 1.
Graphical approximation of Tronto's Framework for Care Ethics (Campbell, Yasuhara, and Wilson 2015)

Fig. 2.
Coding Approach used for Analysis

Table 1

Passage-level Codes for Who is Responsible

Code	Description
Engineers responsible	Passages in which engineers are positively associated with responsibility for the e-waste problem.
Others (non-engineers) responsible	Passages in which others besides (possibly in addition to) engineers are positively associated with responsibility for the e-waste problem.
Unclear with respect to engineers' responsibility	Passages that are unclear in their identification of engineers and/or their association with responsibility for the e-waste problem.
Unclear with respect to others' responsibility	Passages that are unclear in their association of others (non-engineers) with responsibility for the e-waste problem.
Engineers not responsible	Passages in which engineers are negatively associated with responsibility for the e-waste problem.
Others (non-engineers) not responsible	Passages in which others besides engineers are negatively associated with responsibility for the e-waste problem.

Table 2

Essay-level Categories for Acknowledging Engineers' Responsibility

Category	Description
Engineers' responsibility acknowledged, unqualified	Essays in which engineers' responsibility was simply acknowledged without qualification (e.g., without connotations of deflection, reservation, limitation, or sharing).
Engineers' responsibility acknowledged and also shared with others	Essays in which engineers' responsibility was acknowledged but also shared with others with no further qualifications (i.e., without connotations of deflection, reservation, or limitation).
Engineers' responsibility acknowledged, shared, but limited	Essays in which engineers' responsibility was acknowledged and shared with others, but the scope was explicitly limited or constrained in some way (e.g., with connotations of deflection, diffusion, or reservation, or was secondary to or contingent on the actions of others).
Ambiguous with respect to engineers' responsibility	Essays that were ambiguous with respect to the responsibilities of engineers for the e-waste problem (e.g., because they neglected to mention engineers).

Table 3

Prevalence of Stakeholder Categories

Category	# of Participants who indicated one or more stakeholders
Technical/Economic	30
Natural Environment	29
Citizenry	28
Government/NGO	16

Table 4

Breadth of Stakeholder Category Coverage

# of Categories Covered	# of Participants
4	16
3	11
2	3
1	0

Table 5

Coding Results for Who is Responsible for the E-waste Problem

Code ^a	# of Participants
Engineers responsible	26
Others (non-engineers) responsible	22
Unclear in regard to engineers' responsibility	7
Unclear in regard to others' responsibility	1
Engineers not responsible (explicit)	0
Others not responsible (explicit)	0

^aThese codes were applied to passages and are not mutually exclusive in a given essay.

Table 6

Essay-level Results for Acknowledging Engineers' Responsibility

Manner in which Engineers' Responsibility Acknowledged ^b	# of Participants
Without Qualification/Limitation	7
Shared with Others (without qualification/limitation)	10
Shared with Others but Qualified/Limited	9
Ambiguous (with respect to engineers' responsibility)	4

^b These categories were applied at the essay level and are mutually exclusive.