The Whole as the Sum of More Than the Parts: Developing Qualitative Assessment Tools to Track the Contribution of the Humanities and Social Sciences to an Engineering Curriculum

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Abstract
As over sixteen years of experience have demonstrated, outcomes-based assessment under the EC2000 criteria has created a space to recognize the role of the humanities and social sciences in engineering education. At least five of the outcomes derive directly from the humanities and social sciences (HSS), and another three either require or are enriched by HSS perspectives. Assessment according to the various criteria, however, does not provide a sense of the total contribution of the HSS to engineering education. This paper describes an effort to assess the contributions of the field of Science, Technology, and Society to undergraduate engineering education at the University of Virginia. Specifically, it describes a pilot test of what we are calling an "STS Qualifying Exam," which our fourth-year engineering students (over 700 students) took in the Fall 2016 semester. Drawing on the perspective offered in Gary Downey's (2005) article, "Are Engineers Losing Control of Technology?", we consider engineering to rely on both problem definition and problem solution. We designed the Qualifying Exam to assess students’ ability to use sociotechnical analysis to define possible problems and solutions for a novel scenario. We also designed a way to efficiently evaluate over 700 exam essays of about 500 words each. To improve the exam design for future iterations, and to improve the effectiveness of how we teach sociotechnical analysis and other skills through STS courses, we used qualitative analysis to code the best exam essays. With this method, we identified the factors we consider to be hallmarks of good sociotechnical analysis, enabling future evaluation of these hallmarks. This paper describes the rationale for the exam, the factors shaping its design, its results, and what we learned from assessing our students’ skills qualitatively.

In The Engineer of 2020: Vision of Engineering in the New Century (2003), the National Academy of Engineering lays out a vision for engineering in 2020 that emphasizes an appreciation of social, political and cultural complexity as engineering begins to address the “world’s complex and changing challenges” (p. 49). The report calls for a “solid grounding in the humanities, social sciences, and economics… for more effective leadership in the development and application of next-generation technologies to problems of the future.” However, meaningfully integrating humanities and social science content into engineering curricula is challenging and resource-intensive. Given the importance of this particular skill set for the development of the 2020 engineer, it becomes all the more necessary to develop evaluation criteria that can determine how efficiently and effectively students are mastering the contextual skills that are essential for engineering practice and leadership.

As over sixteen years of experience have demonstrated, outcomes-based assessment under the EC2000 criteria has created a space to recognize the role of the humanities and social sciences in engineering education. At least five of the outcomes derive directly from the humanities and social sciences (HSS), and another three either require or are enriched by HSS perspectives. Assessment according to the various criteria, however, does not provide a sense of the total contribution of the HSS to engineering education. This paper describes an effort to
assess the contributions of the field of Science, Technology, and Society to undergraduate engineering education at a particular institution – the University of Virginia. Specifically, it describes the rationale behind what we are calling an "STS Qualifying Exam," which was taken by all students enrolled in an upper level Science, Technology, and Society (STS) class in the Fall 2016 semester (700+ total).

Drawing on Downey's (2005) definition of engineering as both problem definition and problem solution, we designed an exam to assess the ability of engineering students to think comprehensively and broadly about a novel scenario with both technical and non-technical dimensions. In addition to providing comprehensive data about what the STS program adds to the engineering education of all students who pass through our program, we wanted to more precisely articulate what constitutes excellence in sociotechnical analysis of the type we prepare our students to do. Having extensively assessed all of the non-technical ABET outcomes at all levels of our curriculum, we were eager to know whether the sum was more than the whole of its parts, in other words, what students could do when they applied their knowledge to the kind of situation they might face on the job. And we wanted to develop a strategy for reliably assessing what the students produced.

This paper describes the rationale for the examination, the factors shaping its design, and what we learned from the exam about what constitutes excellence in the sociotechnical analysis of the kinds of real-world problems practicing engineers address. Most importantly, it offers evidence that we have at least begun to develop a promising qualitative approach to demonstrating the value of STS in an engineering curriculum.

The Rationale for the Examination: Assessment of Non-Technical Outcomes/Professional Skills

In a white paper endorsed by the Liberal Education Division of ASEE in 2002 and published in the Annual Conference Proceedings that same year, Steneck, Olds, and Neeley (2002) argued that the EC2000 criteria “provide[d] opportunities for more clearly defining and strengthening the role of liberal education in engineering” (p. 1). More specifically, they claimed that “Liberal education can contribute significantly to the development of all the program outcomes defined by ABET and is essential to seven of them” (d-j) and to the requirement that the major design experience prepare students to deal with “economic; environmental; sustainability; manufacturability; ethical, health, and safety; social; and political” issues.1 Recognizing that the new scheme for accreditation specified outcomes but not how the new requirements should be met and that many engineering educators would “have difficulty envisioning how liberal education should be designed and assessed under the new criteria,” the authors articulated the purpose of liberal education in engineering; specified the component skills, abilities, and knowledge necessary to achieving those learning objectives; and outlined the means by which those outcomes could be assessed at three different levels: (1) knowledge and skills, (2) understandings, and (3) values and character.

1 Since that paper was published, the criteria themselves have been revised so that they include the “consider and integrate” aspect as one of the listed outcomes.
As those of us who lived through the transition to EC2000 know, it was far from obvious how outcomes-based assessment would work and whether engineering curricula would come to see “Liberal education as an integral part of engineering education, rather than an extraneous requirement that students must meet” (Steneck, Olds, and Neeley, 2002). One particular logistical challenge was presented by the fact that each of the outcomes had to be assessed separately. A tremendous amount of work was required to develop and implement the tools of assessment. By this time, a huge body of literature published through the ASEE Annual Conference Proceedings and elsewhere documents the success of humanists and social scientists in specifying and assessing the discrete outcomes to which the HSS are most relevant. At this distance, it appears that the assessment process has been more fully realized than the curricular integration that Ollis, Neeley, and Luegenbiehl (2004) envisioned as a possible result of the creation of new curricula under EC2000. Having more or less mastered the process of assessing the individual outcomes, we set our sights on developing the outlines of a process to assess what the humanities and social sciences and STS contribute to the preparation of engineers.

A frequent theme in the various publications that articulated the rationale behind the new criteria is the objective of ensuring “that graduates are adequately prepared to enter and continue the practice of engineering” and that “engineering education can be made more relevant to societal needs in the new millennium” (Parrish in Ollis, Neeley, and Luegenbiehl, 2004, p. 15). While these goals provided the energy behind the vision of EC2000, there was no clear logical bridge between the vision and the discrete outcomes, nor between the various outcomes.

Another challenge was posed by the language of “soft skills” (vs. “hard skills”) and the mental model underlying it. Some of the most tangible evidence of the progress achieved in the last 15 years is that the language of “professional skills” has become pervasive if not universal in the literature on engineering education. Although most conversations assume a distinction between “technical” and “non-technical” (or professional skills), the boundary between the two is not well-defined. Although there is dispute about exactly how many outcomes require an HSS component, it is widely agreed that an ability to function on multi-disciplinary teams; an understanding of professional and ethical responsibility; an ability to communicate effectively; the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context; a recognition of the need for, and an ability to engage in life-long learning; and a knowledge of contemporary issues are included in that category.²

At the University of Virginia, these professional skills are developed through a series of four courses in the Science, Technology and Society program. The first course, taken in the first year, emphasizes developing writing skills, critical reasoning and understanding the role of technology in world history. The second course is an elective which students take in their second or third year. Electives include, but are not limited to, courses focused on technology policy, entrepreneurship, or engineering in other cultures. In the final year of the undergraduate engineering program, students are required to take a two course series STS 4500: STS and Engineering Practice and STS 4600: The Engineer, Ethics, and Professional Responsibility. As

² The task of clearly distinguishing between technical and non-technical skills is, to use engineering terminology, “nontrivial.”
part of these courses, the student produce an undergraduate thesis portfolio that consists of a technical report on engineering research or design, an STS research paper, and a sociotechnical synthesis that establishes the relationship between the two major deliverables of the project. All parts of the portfolio demonstrate the extent to which students have mastered particular outcomes, but none of them directly assesses their ability to apply the professional skills comprehensively in the context of a particular engineering project, in other words, their mastery of the whole to which all of the professional skills contribute.

The STS faculty scheduled a pilot test of the qualifying exam near the end of the fall semester of the fourth year, i.e., after the students had effectively taken three STS courses. At the completion of the pilot, we learned of other efforts to use scenarios to assess professional skills, some of them quite fully developed (see especially McCormack et al. 2014 and Scheckpeper et al. 2012). Those other studies differed from ours in several significant ways:

- Even though they grouped the professional skills together, they measured the outcomes separately. This strategy is understandable given the requirements of accreditation, but it does not clearly relate to one of the original aims of EC2000, which was to equip graduating engineers to address sociotechnical issues in the context of engineering practice.
- They were conducted by researchers whose primary or core expertise was not in the disciplines that contribute most directly to the professional skills, more specifically, almost exclusively by people with advanced engineering degrees. Their engagement with the professional skill-related outcomes is an example of the expansion of horizons and concerns that EC2000 sought to promote. Nonetheless, it limited the depth with which they could articulate their evaluation criteria. As the outline for a scenario designed to assess understanding of professional and ethical responsibility (reproduced below from McCormack et al. 2014, table 6) illustrates, the “ethical issues” are matters of fact rather than principle or theory.
- They were much more time and labor intensive. For example, we assessed the competencies we were interested in using essays of no more than 500 words, which were evaluated by a team of three graduate students and recent PhDs. The scenario we used was drawn from an NPR article, in contrast to the research-heavy approach of gathering sources and creating an annotated bibliography as a prelude to creating and evaluating scenarios.
Table 6. Outline for the E-Waste scenario – ABET 3f

<table>
<thead>
<tr>
<th>Understanding of professional and ethical responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Problem ID</strong></td>
</tr>
<tr>
<td>- Breaking down E-waste for recycling makes the materials available for reuse but also can release harmful material if not handled properly.</td>
</tr>
<tr>
<td>- Crushed E-waste contains carcinogenic agents that can contaminate ground water and are harmful if airborne.</td>
</tr>
<tr>
<td>- It is cheaper to process E-waste in third world locations because of low labor costs and lack of regulation.</td>
</tr>
<tr>
<td>- A change to lead free solder was mandated to reduce the amount of harmful materials in E-waste, but lead free solder has been problematic in practice, resulting in more total waste.</td>
</tr>
<tr>
<td>- Major electronic device companies have instituted recycling programs but are producing more E-waste from shortened product lifecycles and product modifications.</td>
</tr>
<tr>
<td>- E-waste contains valuable materials that are environmentally damaging to extract from natural sources.</td>
</tr>
<tr>
<td><strong>Stakeholders</strong></td>
</tr>
<tr>
<td>- consumers (computers, phones, tablets, laptops, MP3 players, televisions, monitors, printer)</td>
</tr>
<tr>
<td>- manufacturers (OEM)</td>
</tr>
<tr>
<td>- landfill operators</td>
</tr>
<tr>
<td>- regulators</td>
</tr>
<tr>
<td>- reprocessing organizations</td>
</tr>
<tr>
<td>- management</td>
</tr>
<tr>
<td>- workers</td>
</tr>
<tr>
<td>- residents of E-waste producing countries</td>
</tr>
<tr>
<td><strong>Ethical Issues</strong></td>
</tr>
<tr>
<td>- While there are no federal laws, there are many state regulations that prohibit large producers of E-waste from landfilled.</td>
</tr>
<tr>
<td>- Some countries have strong E-waste related laws.</td>
</tr>
<tr>
<td>- Green certification of new products is often a plus in the marketplace but requires lifecycle management of hazardous materials.</td>
</tr>
<tr>
<td>- Technology driven consumer culture has enabled electronics manufacturers to produce products with shorter lifespans.</td>
</tr>
</tbody>
</table>

Table: An example of an assessment of professional skills (McCormack et al., 2014, table 6)

The instructors of the fourth-year course agreed on the following design criteria for the scenario presented to the students:

- The technical aspects of the scenario should give neither an advantage nor a disadvantage to students in particular majors.
- The scenario should focus on a current event but not on topics on which the discourse had already become polarized.
- It should put students in a position they were likely to encounter in the practice of engineering.
- It should provide opportunities for identifying a range of stakeholder or social groups.
After investigating a range of promising scenarios suggested by STS faculty, we settled on the scenario below. (To see the complete prompt, including the supplementary factual details, see the appendix to this paper.)

As the attached article demonstrates, cities around the country are considering whether equipping police officers with body cameras can restore trust between police and citizens and discourage police misconduct. Imagine that you are the lead engineer working with the city council of a mid-sized American city to develop a plan for integrating a network of body cameras into the city’s information technology networks. The city leadership has not purchased the body cameras yet, but they are clearly excited about the potential of body cameras to resolve disputes and restore trust between citizens and local police. The city leaders are looking to you to advise them because your preparation in Science, Technology, and Society (STS) has equipped you to attend to both technical and social aspects of engineering problems. As part of your job, the city leaders have asked you to present a sociotechnical perspective on the use of body cameras to restore trust and prevent police misconduct. Your job is not to tell the city leaders what to do but rather to advise them about what they should take into account in making a decision.

Compose a well-organized argument of no more than 500 words that draws explicitly on at least one STS concept or theory, which you explain and use as part of your analysis. As you prepare your essay, consider the interests and perspectives of the relevant stakeholders, actors, or social groups as they are represented in the following article.

What are the most important non-technical factors that should shape the decision to use (or not use) body cameras? There is no perfect or “right” answer to this question; the quality of your answer depends on clear and logical argumentation and your ability to describe and analyze the situation presented in the article.

Students completed the exam outside of class with a time limit of 75 minutes. (Our students often take timed take-home exams, because of UVA’s Honor Code.) They submitted their response to UVA’s online course management site.

**Evaluation Rubric and Procedures**

The instructors of the course developed the evaluation rubric based on an initial review of a random sample of exams that were submitted early. After more than a few false starts, we settled on a rubric that was almost identical to the one below (with one later change – see *).
### STS Qualifying Exam Rubric

<table>
<thead>
<tr>
<th></th>
<th>Superior Competence</th>
<th>Competence</th>
<th>Developing Competence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(STS) Theory/Concept</strong></td>
<td>Explicitly identified, well explained, applied well to part of analysis</td>
<td>Explicitly identified but not well explained or applied; or implicitly identified and somewhat explained and/or applied*</td>
<td>Not clearly identified or applied to analysis</td>
</tr>
<tr>
<td><strong>Analysis</strong></td>
<td>Identifies non-technical factors and groups beyond those emphasized in the article</td>
<td>Non-technical factors and groups mentioned but much of the analysis simply repeats elements in the article</td>
<td>Non-technical factors largely overlooked, groups/actors only mentioned</td>
</tr>
<tr>
<td><strong>Evidence</strong></td>
<td>Drawn from NPR article (and perhaps other course readings), well explained, supports ideas</td>
<td>Mostly drawn from article, not always well explained, usually supports ideas</td>
<td>Evidence largely absent, unexplained, and/or does not support ideas</td>
</tr>
<tr>
<td><strong>Writing</strong></td>
<td>Well organized (introduction with claim, body, conclusion); ideas expressed clearly and precisely</td>
<td>Some organization, most ideas expressed clearly with occasional lapses</td>
<td>Little organization, difficult to understand</td>
</tr>
</tbody>
</table>

* The graders added this second criterion based on the many competent answers that implicitly discussed STS theories.

**Evaluation Key**

- ✓ Superior Competence
- ✓ Competence
- ✓- Developing Competence
- X Student did not put forth a good-faith effort on the exam

The grading team consisted of one systems engineering graduate student, one Ph.D. in STS, and one Ph.D. in history. None of the three was an instructor for the course. Each exam was read by two graders, who recorded their evaluations on the back of each printed exam. The evaluators did not assign scores on individual dimensions of the rubric. Rather they utilized the rubric as a set of descriptions and exercised their expert judgment to generate a single evaluation for each paper. If both graders arrived at the same evaluation then the evaluation was confirmed. In a case where the evaluations differed, the evaluation recorded was the higher of the two. Although we had anticipated having numerous cases where the two graders differed by more than one scoring level, none occurred. The inter-rater reliability was high. The exams were not graded on a curve or according to any other quota expectations for each evaluation category. The evaluation process was thus primarily qualitative, and fairly efficient in terms of resources and grader time.
The table below summarizes the results of the group as a whole.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Number of Students</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check Plus Plus</td>
<td>69</td>
<td>11.22%</td>
</tr>
<tr>
<td>(Rated as Superior Competence by Both Evaluators)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check Plus</td>
<td>53</td>
<td>8.62%</td>
</tr>
<tr>
<td>(Rated as Superior Competence by One Evaluator and Competence by the Other)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check</td>
<td>413</td>
<td>67.15%</td>
</tr>
<tr>
<td>(Rated as Competent by One Evaluator and Developing Competence by the Other)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check Minus</td>
<td>75</td>
<td>12.20%</td>
</tr>
<tr>
<td>(Rated as Developing Competence by Both Evaluators)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cross</td>
<td>5</td>
<td>0.81%</td>
</tr>
<tr>
<td>(Rated as Inadequate by Both Evaluators)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>615</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

An important benefit of this qualitative assessment is that it allows us as instructors to identify a variety of ways in which students can demonstrate the skills we value in sociotechnical analysis. We want to explore this variety for two reasons: 1) to improve the evaluation rubric for future iterations of this exam, and 2) to improve our teaching, by targeting the skills that students in general struggle with on the exam. Qualitative assessment allows the flexibility to identify both what we value and how students achieved it. For the analysis presented in this paper, we selected the exam papers that received the highest score, which is that both graders awarded the papers a “check-plus”. Because we want to identify what “good” STS analysis looks like, we examined the papers that best achieved the rubric we’d written for the graders. 69 papers earned this score. We divided them among us (the three authors of this paper) and analyzed them for patterns of how the students used STS concepts to interpret the case, how they engaged with the existence of multiple perspectives, and how they addressed the audience (i.e., the city council). We were inspired by Lederman and coauthors’ (2002) method of assessing qualitative responses to judge college students’ beliefs about what science is, based on the authors’ open-ended “views on nature of science” (VNOS) questionnaire. The VNOS asks students to respond in writing to several short case studies. The authors then coded these responses for several criteria, including whether students understand science to be empirical, creative, theory-laden, based on inference, and influenced by social and culture (Lederman et al. 2005, p. 506). Like Lederman et al., we derived our coding system from the data, through grounded theory. After our initial round of coding, we identified some variation in the papers and decided to reduce their number to better
exemplify what we considered to be “good” characteristics of STS analysis. So we each chose the five “best” papers in our third of the “check-plus” papers, and focused on these fifteen papers for the rest of the study.

Next, we discussed the themes we had noticed. We grouped the most interesting themes into three categories:

1. The student integrates STS theory and the case in their argument. This category in its lowest form includes defining an STS concept and explaining the assigned case study. But it includes thoughtful, specific application of a concept to the case, rather than vague statements of why a theory and the case are relevant to each other. An exemplary and rather uncommon achievement of this category is a paper that critiques an STS concept, such as naming its benefits or limitations.

2. The student acknowledges complexity in the case and/or in STS theory. He or she may do this by discussing multiple perspectives, arguing that all stakeholders are equally important, and/or acknowledging the contingency of the situation. Discussions of possible outcomes, such as through thought experiments or their own examples, are good indicators of this category.

3. The student inhabits the role of an expert, by serving as a consultant to the city council as described in the prompt. Ways to achieve this include addressing the city council directly, such as by making specific recommendations as to how they should proceed. Addressing an audience outside of the student’s/engineer’s field is best achieved through a structured, explicit organization of ideas. The student’s paper should sound like an argument that is written to inform and advise the city council, e.g., with a specific point in each paragraph and a clear beginning, middle, and end to the analysis.

We then re-coded the top 15 papers, to check these three codes’ usefulness. We found the themes in most of the papers. The following paragraphs describe how we understand these themes, as indicators of certain skills that are valuable for engineers and that can be learned through studying STS.

**Results: What We Learned About Excellence in Sociotechnical Analysis**

The 15 best exam responses all define an STS theory or concept and apply it to the case of police body cameras, thereby integrating theory and case. The definitions are accurate to the original author’s formulation of the theory, often with a citation. We define “applying” a theory as explaining how it is relevant to the case, such as how it informs the student’s advice for the city council. For example,

The manifest function (or intended consequence) of body-mounted cameras on police officers is to hold said officers more accountable for their actions … Citizens who wish to hold officers more accountable see any technology that solves this problem to be the “missing link” leading to the truth. This results in a latent function (unintended consequence) of the technology being that the truth and what is recorded on these body cameras are synonymous.
This student defines concepts through explanations of the case, and vice versa. The outcome of this approach is to present a problem with body cameras, which is that people may perceive video as truthful when it may not be. This kind of response shows comprehension of the theory and the case, as well as critical thinking and the ability to adopt multiple perspectives.

Several students present the case as an example or demonstration of a theory. For example,

Instead of these social changes that Weinberg (2005) claims would take more effort from the individual, body cameras can be seen as a short-term fix for the larger issue of misreporting details during police-civilian interactions. The student uses Weinberg’s argument that social change can’t be accomplished by technology alone to point out body cameras’ limitation as a “short-term” technological solution instead of a sustainable social approach to improve trust in law enforcement. Several students identify factors relevant to the case and then use a theory to suggest a cause for these factors. For example, “certainly, there are some corrupt and racist police force members. But this behavior could also be explained by the Agentic State phenomenon, where members of an organized agency do things they would never do by themselves.” This student demonstrates the value of thinking about cases in terms of general social patterns.

Most of the best 15 papers express critical and creative thinking and a broad approach to the case, a pattern that we describe as “acknowledging complexity”. This includes discussing the case, a theory, or the work of doing sociotechnical analysis more generally as many-sided or with many possible solutions. For example,

I urge the city council to examine the issue from both sides of the spectrum, socially and technically. Oftentimes I find the solution is somewhere in the gray area in the middle. To correctly identify exactly where it lies, we must examine the different participants involved, their agendas and finally potential solutions.

Others credit applying a theory for revealing the case’s underlying complexity:

At first glance requiring policeman and policewoman to wear cameras at all times easily bridges the gap of trust between law enforcement and the general public … However when ANT [actor-network theory] and the cartography of controversies are applied to the situation, the dynamic changes dramatically.

These examples, as well as many others, suggest considering the perspectives of multiple stakeholders as a way to understand the case’s complexity. The prompt’s focus on identifying stakeholders probably helped inspire this point, but it is also a common theme in STS theories.

Another way students demonstrate their comfort with the case’s many variables is by explaining their ideas in the form of thought experiments. These are situations or factors that students invent and do not appear in the exam’s prompt or news article. For example,

[Police] may also be less likely to take other actions to improve community relations if body cameras have such a good reputation for doing so. Reformers or vigilantes may be less likely to record police incidents if they know body cameras are already recording them, missing key opportunities to record a potentially useful perspective.

Discussing possible changes in behavior due to the implementation of cameras is insightful and shows a strong awareness of the relevance of people to the success of new technologies.
Describing actions as conditional, e.g., that people “may be less likely to”, shows an understanding that there are many possible outcomes of this case. For example,

A police car is an actor in the implementation of a dashboard camera because it will determine the angle at which an encounter is being filmed. The absence of the vehicle would necessitate a face-to-face confrontation that could change the entire encounter.

The student sets up an imagined but realistic scenario, i.e., that not being in a car “would necessitate” different behavior by the police officer and citizens and therefore needs to be considered in the decision about body cameras. Using test cases like this helps students clarify their ideas and make their advice more compelling.

Similarly, students embrace complexity by raising questions not mentioned in the prompt or news article, contributing additional relevant factors and demonstrating their understanding of the case as involving many people and systems. For example,

Additional factors to be considered include the economic tradeoff the up-front and maintenance cost of cameras will require—in other words, where will the money come from?

One student wrote a long list of questions that the city council should ask:

What is causing police to act inappropriately? Why did the police lose trust in the first place? Are their [sic] underlying racial tensions? … Could we institute more appropriate training or harsher penalties for misconduct? What is the importance of public trust?

These are all questions we need to ask at the interpretivist level to understand what problem the cameras are trying to fix.

By framing the situation as an experiment with unknown variables and results, students engage deeply with the specifics of the case as well as with the more general skills of defining problems and developing ways to solve them. They acknowledge that sociotechnical situations are complex, and, crucially, they are not afraid to further complicate a case by bringing up their own ideas of relevant factors and possible outcomes. Rather than striving to simplify the exam case, the best papers willingly complicate it.

Another characteristic shared by many of the best papers is what we call “inhabiting the role of expert.” By this we mean that the students adopt the role of an advisor asked to share their STS expertise with non-experts, as specified in the prompt. They demonstrate this role by addressing the city council directly and making specific, normative recommendations. Making recommendations is making an argument, supported by evidence and logical reasoning. Students who did not do this generally wrote generic descriptions of the news article and a theory, without a normative or argumentative voice. In addition, we include the logical organization of ideas as a crucial component of writing as an expert for an audience of non-experts. The best papers are all structured clearly, with ideas in logical order.

Making specific recommendations to the city council implies that the students see their STS knowledge as useful in real-world cases. A few students suggest technical alterations to the cameras, such as “The city council should explore options for automated recording.” But most students recommend institutional and training changes, such as these five students’ ideas:

There should not be ambiguity around when to use the camera, and there should likely be serious repercussions if the policies are violated.
Successful implementation of body cameras would also involve appropriate funding for this technology and research surrounding it by state and local governments.

In addition to the body cameras, the city would be well advised to have more rigorous screening and training of their candidates in order to ensure only those who genuinely want to protect and serve are given the immense responsibility of being a police officer.

I recommend that the city council consider the cognitive belief systems, behavioral norms, and formal regulations that underlie the different interpretations of the relevant stakeholders. For example, jurors in a court case with video evidence should be educated in the bias and fallibility of recorded images to eliminate the belief that videos are not value-laden.

I would also caution the council against merely applying a technological fix to a problem that has deep social roots. The use of body cameras may be an important component of a program to restore trust between police officers and those they serve, but it should not be the only component.

This advice ranges in tone from “should consider” to “would have to change”. They all express a conditional sense of what to do if the cameras are adopted, but with a variety of levels of forcefulness. The groups affected by these recommendations range from the police, government, and jurors, reflecting students’ embrace of the multi-stakeholder approach to understanding sociotechnical situations. Another category of recommendations focuses on research and mindset. For example, some students urge leaders to stay open-minded, e.g., “It will be important for the city council to try to employ interpretive flexibility when research[ing] and anticipating the potential responses to the decision.” Others call for research to guide policy: “A careful analysis on all of the stakeholders involved and the specifications of the technology and how that shapes its use needs to be conducted, in order to draft a detailed and comprehensive plan for wide-scale deployment.” Defining research and mindset as equally important steps as policy changes is a powerful indicator that students see sociotechnical analysis – and social factors – as valuable.

In summary, the best of the papers that our assessment process identified all exhibited these three characteristics: they (1) integrated STS theory and the case in their argument, (2) acknowledged complexity, and (3) inhabited the role of the expert by making arguments written to inform a decision-making process.

Conclusions and Next Steps

The evidence we collected to illustrate each of these characteristics provides a thick description of our emerging conception of excellence in sociotechnical analysis. This thick description will be particularly useful for refining the assessment process as we iterate on the approach used for the pilot. For example, it may be advantageous to revise the exam rubric to more adequately account for these characteristics. It was clear to us that the sample of papers that rose to the top were filtered through the initial rubric and may have under-represented papers that modeled our three characteristics in less conventional ways. A revised rubric could allow for a more thorough evaluation and assessment.
We see potential for this approach of holistic assessment to be useful outside of UVA, especially for other institutions’ evaluations of how HSS and STS contribute to engineering education. Engineering educators already value assessing technical skills through real-world case-study evaluations, such as in capstone research and design projects and in the Principles and Practice of Engineering (PE) exam. The difficulties of assessing students’ abilities to integrate their various kinds of knowledge are also present in these technical activities. Our approach can help pave the way for identifying indicators of students’ integration of information and holistic critical thinking across subjects and skills. Also, it was clear from the spread of the evaluation and the high inter-rater reliability that the current structure of the assessment is sufficient to make reasonable judgments about students’ ability to conduct sociotechnical analysis. The 500-word limit that was initially driven by efficiency concerns has proven to be more than adequate for the assessment.

Our goal is to further develop this method and mindset of holistic assessment through future annual iterations of the STS Qualifying Exam, including additional research and reflection methods. For example, we have collected but not yet analyzed data on the students’ perception of the exam and its relationship to the educational experiences that led up to it. Anecdotal evidence suggests that the exam served an educational function as well as an assessment function. One interesting complication unearthed by our analysis concerns the influence of both the prompt and instructor coaching on the responses of students. In other words, in what ways could we improve our teaching to more fully embody the identified three characteristics? We will work to separate and discern those influences moving forward. We also suspect that the strong points of the top-rated exams we analyze here would be clearer if they were contrasted with responses from the weaker exams. These are all areas for future work.

Returning to the notion with which we began this paper, at the onset of this process we envisioned a number of clear goals and outcomes including (1) assessing the value of skills learned from liberal education and engineering and society (LEES) for engineering practice, (2) creating a qualitative assessment process that enables identification of the multi-dimensional expertise that LEES is meant to introduce to engineering education, and (3) developing an efficient qualitative assessment procedure. At the conclusion, it has become clear that while these goals have all been achieved, the greatest takeaway for us is the opportunity that the process has provided for reflecting on our teaching and how to improve it. The whole is indeed greater than the sum of the parts, both for our students’ sociotechnical education and for our beliefs about holistic assessment.
References


Barry, B. E. and Whitener, J. (Spring, 2014). Impact of professional skills on technical skills in the engineering curriculum and variations between engineering sub-disciplines. Teaching Ethics, pp. 105-122.


Appendix A: Complete Exam Prompt, Including Supplementary Materials

STS Qualifying Exam
Essay Prompt

As the attached article demonstrates, cities around the country are considering whether equipping police officers with body cameras can restore trust between police and citizens and discourage police misconduct. Imagine that you are the lead engineer working with the city council of a mid-sized American city to develop a plan for integrating a network of body cameras into the city’s information technology networks. The city leadership has not purchased the body cameras yet, but they are clearly excited about the potential of body cameras to resolve disputes and restore trust between citizens and local police. The city leaders are looking to you to advise them because your preparation in Science, Technology, and Society (STS) has equipped you to attend to both technical and social aspects of engineering problems. As part of your job, the city leaders have asked you to present a sociotechnical perspective on the use of body cameras to restore trust and prevent police misconduct. Your job is not to tell the city leaders what to do but rather to advise them about what they should take into account in making a decision.

Compose a well-organized argument of no more than 500 words that draws explicitly on at least one STS concept or theory, which you explain and use as part of your analysis. As you prepare your essay, consider the interests and perspectives of the relevant stakeholders, actors, or social groups as they are represented in the following article. What are the most important non-technical factors that should shape the decision to use (or not use) body cameras? There is no perfect or “right” answer to this question; the quality of your answer depends on clear and logical argumentation and your ability to describe and analyze the situation presented in the article.

You have until 9 PM on Sunday, November 13 to complete your essay and upload it to Collab. You may think about your response for as long as you wish, but you only have 75 minutes to type your essay. You may not prepare notes, an outline, or a draft prior to 75-minute window during which you compose your response. You may consult readings and class materials from courses you have taken at the University of Virginia while planning and typing your essay. You are not permitted to consult any other outside sources (e.g. books, articles, websites, e-mail, other students, instructors, etc). Instead, rely on the knowledge you have gained thus far in your academic training, and use the information in the following article as evidence to support your ideas. If you need to cite a source other than the following article, include the author’s name, the title of the source, and page number(s) in parentheses at the end of the sentence. Be mindful of the time, as you only have 75 minutes to write your essay. Please do not discuss the contents of the exam with other students until after the deadline of 9 PM on Sunday, November 13.

Please submit the document as a PDF to the “STS Competency Exam” folder in the Assignments section of your STS 4500 Collab site. At the beginning of your essay, include a heading with your name, your STS 4500 section number and instructor, your SEAS major, the date on which you took the exam, the time you began and finished the essay, and a word count (do not include the heading in the word count). Please use 12-point New Times Roman and one-inch margins, and include page numbers in the document. Type the honor pledge and your signature at the end of your document.
Ferguson, Mo., found a degree of civic calm this week after days and nights of angry clashes between protestors and the police.

Now the city is working to restore trust with residents after a white police officer fatally shot black teenager Michael Brown on Aug. 9. City leaders and residents say one way to do that might be to equip police with personal video cameras.

"All the cops have to have body cameras and dashboard cameras," says resident Alonzo Bond, "so everybody can be accountable."

Earlier this week, the city of Ferguson said it was "exploring" the possibility of buying dashboard cameras and body cameras for its police department. And Ferguson is not alone. Around the country, body-worn cameras have become the go-to technology for troubled police departments.

Police chiefs are just as enthusiastic about the cameras as police reformers, sharing a belief that the cameras can resolve disputes by recording what really happens.

"Everybody's got their version of a story, but when it's on tape, it's on tape," says Philadelphia Police Commissioner Charles Ramsey, president of the Police Executive Research Forum. "It is what it is."

But is it? Howard Wasserman, a law professor at Florida International University who has written about police cameras, says lawyers are starting to discover what any college film student could have told them: Recorded images are not neutral.

"How the camera is held, the angle at which the camera is held, is the camera sort of panning, is the camera held steady — all of that affects the perception of what you see," Wasserman says.

He says in court, video — even if it's fragmentary or confusing — has the potential of becoming the star of the show.

"The problem that I think we get into is the assumption that the video shows all, so we can disregard all the other evidence that's not the video," Wasserman says.

The other big concern with police videos is control. In New Orleans, where all patrol officers started wearing the cameras this spring, the department has given officers mixed signals about when to press the record button, says Susan Hutson, the city's independent police monitor.

"We saw the department was struggling with that a little bit, trying to make sure that officers knew when they can turn it off and when they can't," Hutson says.

Even when an officer willfully refuses to record, it's not a fireable offense in New Orleans. Then
there's the potential for technical glitches, which has long been an issue with the dashboard cameras. They frequently malfunction, and one of Hutson's staffers says it's "suspicious" how often the cameras seem to fail to record at crucial moments — a complaint heard in other cities.

Finally, there's the matter of the 30-second buffer. When an officer presses record, the camera saves the 30 seconds of images that led up to that moment, but not the audio. The manufacturer designed the buffer to protect the privacy of police officers — and to appeal to resistant police unions — but it also means the cameras may miss crucial noises or words that trigger an incident. Wasserman thinks that's a mistake.

"I think if we're going to do this, we need to do it right," he says. "If anybody's privacy is going to be compromised, it ought to be the government officials who are wielding the power in all of these encounters."

He says that's another argument for more video recording by civilians to fill in the gaps of what "really happened" — now that that's increasingly decided by what's captured on camera.