Researching the Impact of Cal Poly Classes on Computing Students Perceptions of Computer Ethics and Social Responsibility

By

Annie Joss

A Senior Project submitted

In partial fulfillment of the requirement for the degree of

Bachelor of Science in Computer Engineering

Computer Engineering Department

California Polytechnic State University

San Luis Obispo, CA

June 2022

Abstract

The importance and impact of socio-technical systems are playing an increasing role in the education of computing students. Discussion of ethics and social responsibility has always been a tenant of computer science education; however, research has shown engineering and computer science students lose focus on these values over their engineering education. Cal Poly computing departments have taken steps to emphasize social responsibility and ethics through required and suggested courses. This project focuses on examining the values and beliefs of Cal Poly computing students, who were surveyed over Winter and Spring Quarters in 2022. This project is inspired by Dr. Cech's work around disengagement in engineering education and her methods were used in this work to determine if Cal Poly computing students are disengaging from beliefs relating to social welfare and responsibly. The results of the survey of 71 Cal Poly computing students showed that overall Cal Poly students view beliefs relating to ethical and social responsibility as more important than engineering students from past research. Students perceived that the department viewed ethical and social issues as important, as well as their own personal views. It was found that students' public welfare beliefs were higher farther along in their degree and students who had taken relevant classes also demonstrated higher public welfare beliefs. Demographic analysis did not reveal any relationship when studying students' more general values outside of the engineering profession. This project demonstrates that the efforts the Cal Poly computing departments took have had a positive impact on student values. This work highlights how an intentional curriculum can have positive effects as well as discussing future areas of improvement.

Table of Contents

Introduction

Social responsibility and ethics are important values in creating strong and effective computing professionals. These values have been important in the university education of computer scientists since the beginning of the discipline. Over the last two decades the internet has become a global and everyday facet of people's lives and the social and ethical impact of the decisions computer scientists and developers have become even more visible. From social media [1] to surveillance through data [2] to algorithmic bias in artificial intelligence [3], ethical and socially responsible design has become a central part of the education future engineers and developers should be receiving. Introducing these values at the early stages of such an analytical discipline may also aid in the recruitment and retention of girls and women to computing majors. On average, women are more likely than men to say that they prefer work with a clear social purpose [4].

Cal Poly's computing departments understand these needs and have corresponding learning outcomes for students. The Computer Science (CS) and Software Engineering (SE) department has a department learning objective of "recognize professional responsibilities and make informed judgments in computing practice based on legal and ethical principles" [5] correlates to their Philosophy class requirement Ethics, Science, and Technology. The recent created Computer Engineering (CPE) Department has also introduced an ethics requirement to their curriculum. Many relevant classes related to machine learning, artificial intelligence, privacy, and security also discuss ethics and professional responsibility in their classes. Given these requirements, how impactful is the Cal Poly curriculum in educating students on this topic? This is the question this work hopes to answer.

Past research from Dr. Cech showed declines in public welfare beliefs in engineering students over their university education [6]. The survey questions were used in this research, and

the findings of this work suggest that taking relevant classes increased Cal Poly students' beliefs that ethics and social responsibility are important in their careers. Cal Poly students' perception of public welfare beliefs is on average higher overall what was found in previous [6] and other replicated work [7]. This paper details the results found in this research as well as highlighting future steps the computing departments could take.

Related Work

Background in research question methodology

Research has shown that computer science and engineering majors show a decline and disengagement from considerations of social welfare and commitment to global citizenship as they progress through their degree [6] [8]. Dr. Cech from the University of Michigan created a long-term study analyzing the public welfare beliefs of engineering students including ethics and the impact of socio-technical systems. In her study, Cech follows four public welfare beliefs among students: professional/ethical responsibilities, consequences of technology, understanding how people use machines, and social consciousness. Additionally, Cech measures the cultural emphasis that the students engineering departments places on technical and non-technical factors. These factors are ethical and/or social issues, policy indications of engineering, broad education in humanities and social sciences, writing skills, basic research, background in math and science, innovation, advancement of scientific knowledge, and invention. Her results show that all four public welfare beliefs decline over time in the engineering program, and the technical factors were perceived as more important than non-technical factors, with ethical and social issues of lowest scoring importance [6].

Research was also done through the national IDEALS study, which measures how student's worldviews changed from the beginning to end of their college career. Computer science majors had a bigger decrease in their global citizenship score than engineering, and engineering and CS had the biggest decreases out of the majors measured by a substantial margin [8].

How current ethics curriculums have been implemented

Many educators are aware of shortcomings in effectiveness of ethics education for the current computer science curriculum in colleges and universities. These shortcomings can be seen in the culture of the discipline: though computer ethics have been emphasized since the beginning [9], meritocracy and innovation have continued to be prioritized over socially responsible computing.

Brown University, Harvard University, Rice University and Stanford University have all created new curricula for computer ethics in their schools [10] [11] [12] [13]. Cohen et al. described Brown's new model for socially conscious computing spans the whole degree program, with an emphasis on integrating responsible computing throughout many classes. This model uses socially responsible computing TAs (STAs) that helped create assignments and facilitated conversations. After one year of this model, Brown found that students took assignments more seriously if the professors went over the ethical relevance in lecture as well as lab assignments and that STAs were valuable in helping ensure the assignments were effective and received well by their peers in the class. Cohen et al. found that standalone courses on computing ethics are necessary and valuable to span the knowledge gaps in-between the focuses in technical classes [10]. Reich et al. details the multi-disciplinary course at Stanford designed to shift how students think about their role within technological change in society. This class appears similar in topics to Cal Poly's CSC 300, though this class was taught by the professor from three departments: computer science, philosophy, and political science. Reich et al. reports that the students found all case studies effective, and an especially engaging part of the class was the multidisciplinary approach with lectures from all three professors [11].

Ethics exercises outside of classrooms have also been created and used to measure the current aptitudes of students to ethical and security mindsets [14] [15]. Krishnamurthi and Young found that undergraduates can meaningfully apply adversarial thinking, thinking like an attacker which is an important mindset for computer security, inside and outside of security contexts. This demonstrates that teaching an adversarial mindset is more accessible to younger computing students than some may have thought [15]. Gray et al. engaged students in a pragmatic exercise to demonstrate their understanding of ethics in a real-world design simulation. Results found that even when students may have been aware of the ethical concerns, it did not result in 'ethically

sound decisions', though this negligence could be due to the academic nature of the environment and absence of real-world consequence [14].

Methodology

Main Survey

In order to assess Cal Poly student's perspectives on ethical and socially responsible computing, we conducted a survey based off of the work of Cech [6] and the IDEALS study [8]. Basing the survey off of this previous research allows us to quantitively analyze how Cal Poly students' beliefs on social responsibility and public welfare compare to other university students. The survey was sent out through a variety of channels to computer science, software engineering, computer engineering, and liberal arts and engineering studies majors as well as and computer science minors and other students who have taken classes within the computing departments. We received 71 responses from targeted classes and an expanded student population using department newsletters and club communications. A summary of respondents' demographics can be found in Table 1. The survey was conducted anonymously through Microsoft Forms. The survey itself can be found in Appendix A.

The demographic data collected by the survey included school year, gender identity, major, and relevant classes taken. The demographic data points differ from Cech's research in some respects. This research is categorized by major instead of university and includes school year because the survey was only conducted once. The rationale for surveying relevant classes will be discussed further on. Overall, 63% of respondents were 4th+ years, 24% were 3rd years, and 13% were 2nd years. The gender ratio of respondents is higher than the national gender ratio for Computer Science graduates, which was 21% female in the 2018-19 school year nationally [link], and 35% for this survey. Dr. Cech's research had a higher percentage at 46.6% when surveying engineering majors in general. We also acknowledge that we received 2 responses from nonbinary or gender nonconforming students, however, there were too few responses to be included as a

statistical category therefore we chose to add to the female category as the other gender minority. The threats to validity are discussed in the next section.

Table 1: Survey Respondents based on demographics

Variable	Number (Total = 71)	Percentage
Year		
1st	0	0%
2nd	9	13%
3rd	17	24%
4th	44	63%
Major		
Computer Science	41	58%
Computer Engineering	18	25%
Software Engineering	6	8%
Other	6	8%
Gender		
Female	25 (27)	35% (38%)
Male	44	62%
Non-Binary	2	3%

Classes relevant to ethical and socially responsible computing were selected from the computer science and computer engineering curriculums in order to collect data from students who have taken these classes specifically. Collecting data from relevant classes is an informative demographic because it allows comparison between students who have taken class that have likely emphasized the beliefs and perspectives this research is surveying and students who have not. These classes were selected because they either directly discuss social responsibility in engineering and computing ethics or are technical classes that touch on ethics and social responsibility because the topic is directly impacted by them (e.g. Artificial Intelligence). The list of relevant classes can be found in Table 2.

Table 2: List of CS/SE/CPE Classes Relevant to Social Responsibility and Ethics (offered in Winter 2022)

Technical Classes	Non-Technical Classes
DATA 401 Data Science Process and Ethics	CSC 300 Professional Responsibilities

CSC 490 C++ and Social Justice CSC 321 Intro to Computer Security DATA 301 Intro to Data Science CSC 480 Artificial Intelligence CSC 466 Knowledge Discovery from Data CSC 487 Deep Learning	PHIL 323 Ethics, Science, and Technology ES 350 Gender, Race, Culture, Science & Technology ES 351 Gender, Race, Class, Nation in Global Engineering Development

Two surveys were used as reference in this research. The first is the IDEALS (Interfaith Diversity Experiences and Attitudes Longitudinal Survey) research. One part of the study measures the student's citizenship at the beginning and end of their college career. The citizen score is the combination of how much students agree with the following four statements: I am actively working to foster justice in the world; I frequently think about the global problems of our time and how I will contribute to resolving them; I am currently taking steps to improve the lives of people around the world; I am actively learning about people across the globe who have different religious and cultural ways of life than I do. The results of these citizenship questions can show how much students feel an active responsibility to work actively for the world around them.

The other survey used as a reference is Dr. Cech's paper "Culture of Disengagement in Engineering Education?" from 2014. Cech examines four public welfare beliefs, with the fourth being 'social consciousness', a scale measure that captures the importance to respondents of improving society, promoting racial understanding, helping others in need, and being active in their community. In this research the last measure, 'being active in their community' was replaced with 'technology being used to positively impact society.' This change was made to include slightly more technology specific questions and allows this measure to be compared to the other more general social consciousness prompts. Additional questions included the respondent's perception of what topics their department finds important and perceived importance of topics to respondent's future career. These questions allow observation of perceptions of the department's impact and respondent's futures. The future career questions were changed in order to address the future concerns of computer science and software engineering careers more directly.

Threats to Validity

Though this survey was voluntary, we do want to explicitly address potential threats to validity. There is potential for a selection bias as this survey was distributed to many classes, department email lists, and club communication and there was no requirement or incentive to complete the survey. There is a considerable likelihood that students who care about ethics within computer science are more likely to respond to a survey about the topic than students who may find the subject irrelevant. Additionally, students from the relevant classes were asked directly to take the survey, and due to their decision to take the class they may understand the importance of this topic more than the average CS/SE/CPE student. Lastly, the skew towards the older ages can be attributed to publishing the survey to classes with predominately 3rd and 4th year students.

Results

Department Perceptions

This question gives insight to how respondents perceive the CS/SE/CPE departments emphasize technical and non-technical factors in education. Students ranked each factor from Very Unimportant (1) to Very Important (4) to their department. In her research, Cech found that if students perceived a higher emphasis on non-technical factors that were engagement-related to public welfare there was a direct impact on their public welfare beliefs. Cech's analysis showed that if students thought their department emphasized Ethical/Social issues, they are more likely to find all four public welfare beliefs (see Methodology) are important [6]. Figure 1 below presents the mean values of these scores side by side, with technical factors in green and non-technical factors in purple.

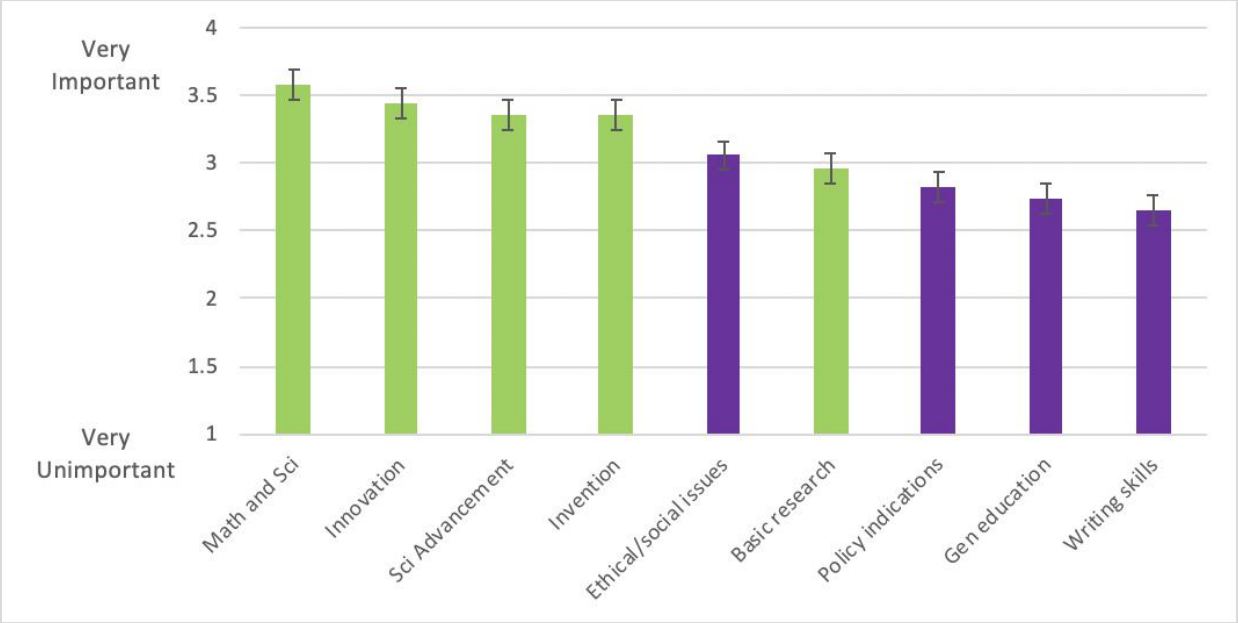

Figure 1: Cultural emphases of students' major departments. Note: Each bar represents the mean value on that cultural emphasis measure for students at time 1. Green bars represent means on the ''technical'' cultural emphases and the purple bars represent the means on the non-technical cultural emphases.

The results of this data show a lot of similarities with Cech's results with a few notable differences. Overall, the technical factors are perceived by students to have more importance within the department. Background in math and science, Innovation, and Advancement of scientific knowledge lead the chart. Consistent with Cech's work is the difference between the most important factor and least important factor, which is a difference of 1. Student respondents on average perceived Ethical and Social Issues to be somewhat important (3.06) to their department. This is higher than students in Cech's research which had an average of 2.77. Our data correlates positively to Cech's analysis that higher perception of a department's importance of ethical and social issues, as the public welfare responses were higher than in Cech's research. Additionally, in Cech's research Ethical and social issues was the least important factor on average, and Cal Poly students on average perceived it to be the fifth most important factor of the nine described, including beating the technical factor basic research. On average this data demonstrates that the Cal Poly students perceive that their departments treat all of these factors as somewhat important and this importance impacts their public welfare beliefs.

Public Welfare

What makes a successful career?

This question provides insight into the extent to which students attribute public welfare beliefs as relevant one's career. These three public welfare beliefs (professional and ethical responsibilities, understanding the consequences of technology, and understanding how people use machines) have overall been perceived as generally tangential to engineering and computer science education due to disengagement (Cech). Understanding students' responses to these questions can help to show whether students are more engaged or disengaged from the realities of how engineering impacts society.

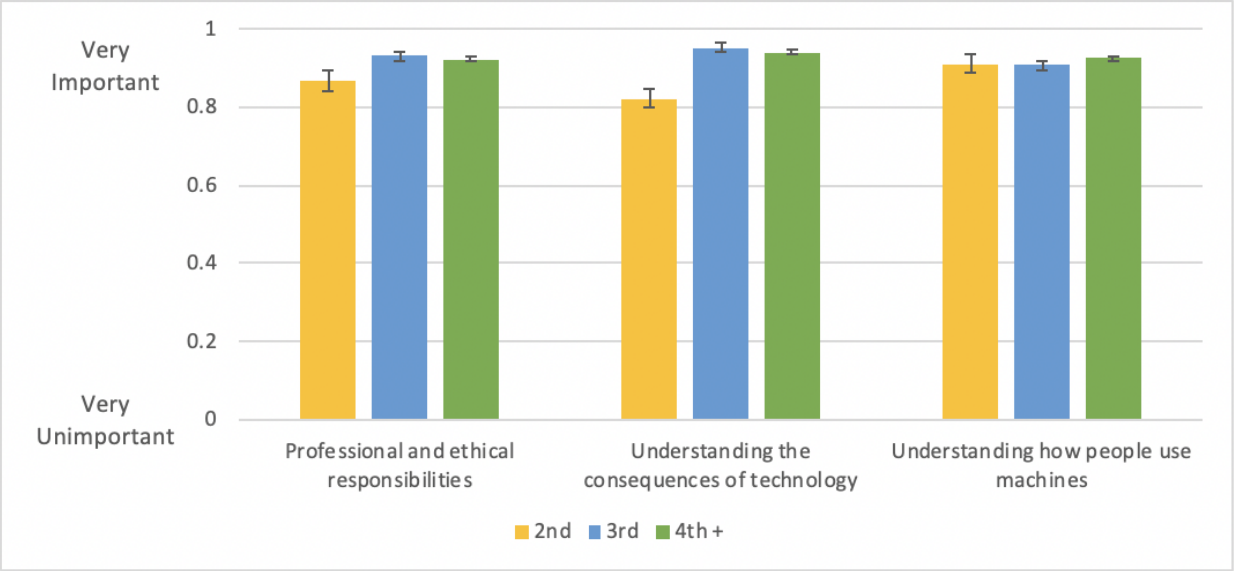

Figure 2: Public welfare beliefs among computing students at different years in their respective degrees. Note: Each bar represents the mean value on that measure for each grade. Means were scaled to a 0 to 1 range ([mean - 1]/5).

Based on Figure 2, it is clear that for all three of the public welfare beliefs perceived importance increased for 3rd and 4th students, either significantly or slightly. This is positive because it demonstrates that students who have spent more time at Cal Poly place more importance on public welfare beliefs in relation to their careers. This data also demonstrates difference from Cech's data because her data showed students public welfare beliefs declined between T1 (freshman year) and T2 (finishing their degree). While the comparison cannot be direct because different second, third, and fourth years were surveyed, the data stands on its own. Additionally, student responses were higher than Cech's research for every category except second years'

understanding the consequences of technology. This means that on average Cal Poly students perceived public welfare beliefs to be more important that students from past research.

Personal Importance of Social Consciousness

These questions were also contributed by Cech's research and aim to explore social consciousness as a public welfare belief, where social consciousness is an average combining the results of the following factors: improving society, promoting racial equality, and helping others in need. One other factor was not included, instead we also surveyed students on the importance they placed on technology being used to positively influence society. Due to the question change, the results cannot be directly compared to Cech's results. However, figure 3 shows that there is a decline in the public welfare belief of social consciousness. Additionally, the added prompt which focuses on technology impacting society rather than society itself is perceived as more important than the other factors of social consciousness. This data shows that social consciousness within students could be encouraged more.

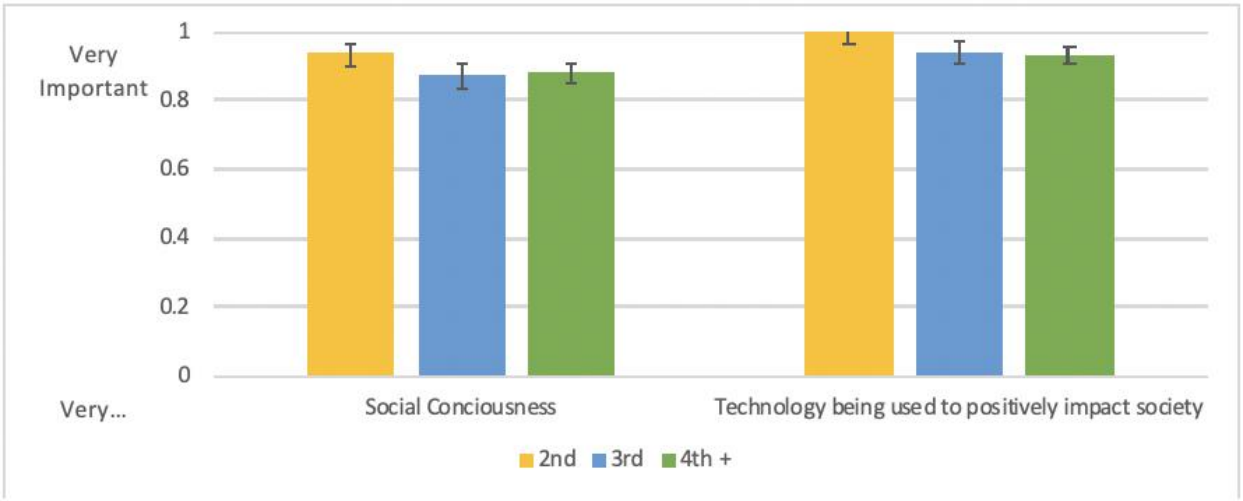

Figure 3: Social consciousness measures among computing students at different years in their respective degrees. Note: Each bar represents the mean value on that measure for each grade. Means were scaled to a 0 to 1 range ([mean - 1]/5).

Another demographic that we looked at the data through is by types of classes taken . Respondents checked whether they had taken any relevant classes, technical and non-technical, that involved discussions on ethics and socially responsible computing. Students have either taken

both technical and non-technical, one or the other, or no relevant classes. Figure 4 shows the results of the public welfare questions based on classes. Clearly some of the factors were not influenced by the types of classes taken, students who had taken no relevant classes had similar views on understanding how people use machines, social consciousness, and technology being used to positively impact society as their peers who had taken relevant classes. The first factor that did seem to be influenced by classes is professional and ethical responsibilities. Having taken any relevant coursework increased the perception that this factor was important to a successful career. This correlates to the department perceptions and Figure 1 because respondents perceived that ethical and social issues were of more importance to the department than respondents in Cech's research. Additionally, from my personal experience, more classes focus on individual professionalism and ethics than overarching social impacts and consequences.

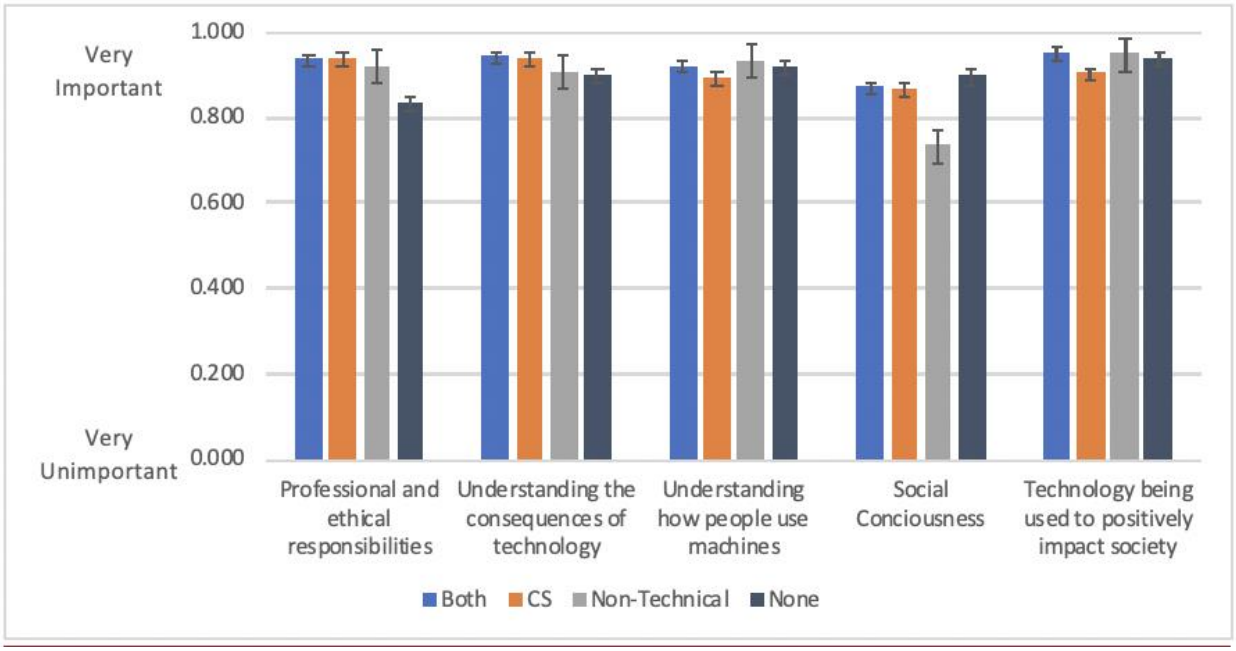

Figure 4: Public welfare beliefs and social consciousness measures among computing students with differing relevant coursework. Note: Each bar represents the mean value on that measure for each coursework. Means were scaled to a 0 to 1 range ([mean - 1]/5).

In addition to finding out which classes respondents had taken that we had deemed relevant, we also asked them to list other classes they had taken that were similar to our technical and non-technical classes. Some notable computing classes listed were CSC 313 Teaching Computing, CSC 422 Network Security, CPE 101 Fundamentals of Computer Science, and CPE 316 Microcontrollers. The rest are listed in Table 3.

Table 3: Suggested coursework relevant to ethics, public welfare, and responsible computing

Suggested additional relevant coursework
CSC 313, 422 CPE 101, 316 PHIL 230, 231, 322, 327,331, 335,336 ISLA 123,202 POLS 308, 420, 426, 427* WGS 201, 370 ES 256

*POLS classes that were deemed irrelevant were omitted

Global Citizenship

This question asked students how much they agreed with the four statements at this point in their life that are related to active engagement, physical or mental, in making the world a better place. The answers were then combined into a global citizenship score, seen in Figures 5 and 6. These questions give insight into how much computing students are considering and engaging in global and civic problems. Our research was interested in how students at different points in their degrees (Figure 5), as well as students who had taken relevant classes (Figure 6), had any differences in agreement of these global citizenship statements.

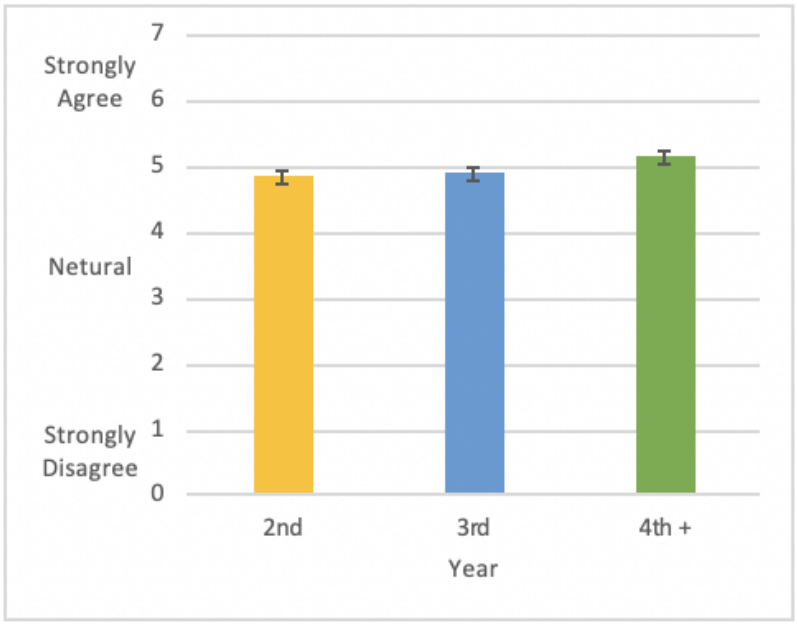

Figure 5: Global Citizenship measure among computing students at different years in their respective degrees. Note: Each bar represents the mean value of the four statement scores related to global citizenship (1 = Strongly Disagree, 7 = Strongly Agree).

When comparing responses by year, there is only a subtle trend of global citizenship increasing as time at Cal Poly increases, however all answers stay around “Somewhat Agree” to all four questions. This global citizenship question comes from another study that analyzes the same group of students over time and therefore a direct comparison is not acceptable. However, it is notable that in the original study Computer Science students’ global citizenship scores changed by -4.4% [8]. Our respondents demonstrated an increase over time, not a decrease, therefore the computing curriculum does not appear to be demonstrating a significant negative culture of meritocracy and disengagement.

In order to find out if relevant classes had any impact on these perspectives, citizenship score was also broken down by coursework in Figure 6. With this breakdown there is a clear difference between students who have taken relevant coursework versus those that had not. This shows that relevant coursework does seem to have an impact on students. Students who had only taken non-technical classes were highest. This makes sense to some extent because philosophy and ethnic studies classes place a larger priority on discussing concepts related to global citizenship because it is more directly relevant to their content. It is surprising that students that have taken both technical and non-technical relevant classes have a lower citizenship score than non-technical only. It makes it clear that these findings are observations, not facts. A more robust surveying of students may not have the same results.

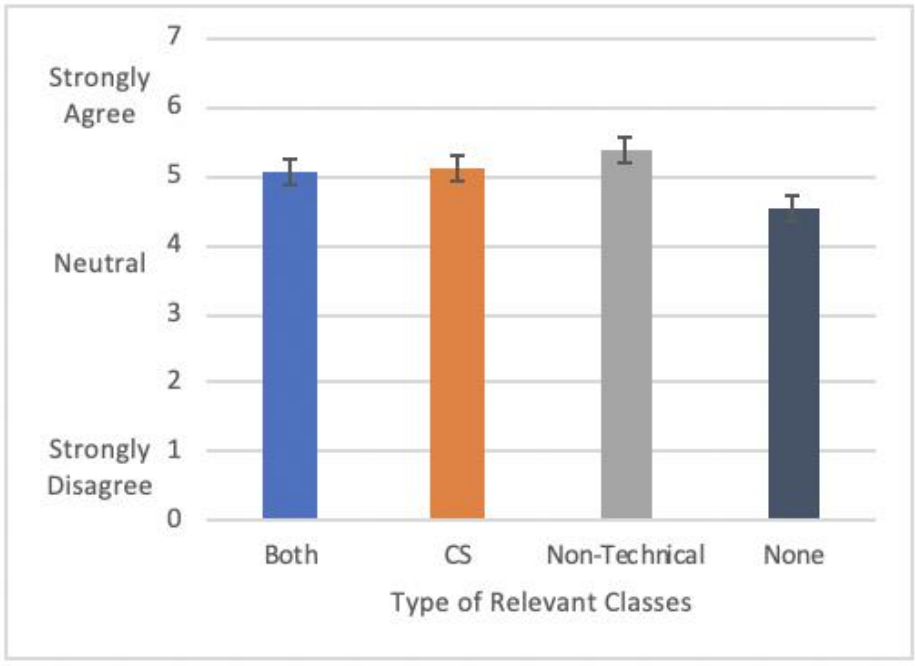

Figure 6: Global Citizenship measure among computing students with differing relevant coursework. Note: Each bar represents the mean value of the four statement scores related to global citizenship (1 = Strongly Disagree, 7 = Strongly Agree).

Importance to Future Career

The question about which factors students perceive as important to their careers gives an insight into how relevant these ideas are to students as they go into the workforce. Cal Poly wants to educate students and instill values and measuring how much students perceive these factors as important is a way to determine if Cal Poly is succeeding. Two factors relating to ethics and responsible computing were chosen and can be compared to the three non-related factors.

When comparing responses by year, many of the categories did not have a clear pattern. Figure 7 shows that between second years and fourth years the importance of social implications of technology on one's future job decreased. This data agrees with Cech's research, unlike earlier data, which indicates that personal importance is more varied than Cal Poly students understanding of a general computing professional. It may also be due to the prompt "social implications of technology" is more ambiguous in its relation to public welfare or professional responsibility. Figure 8 also does not show any patterns or trends in the data.

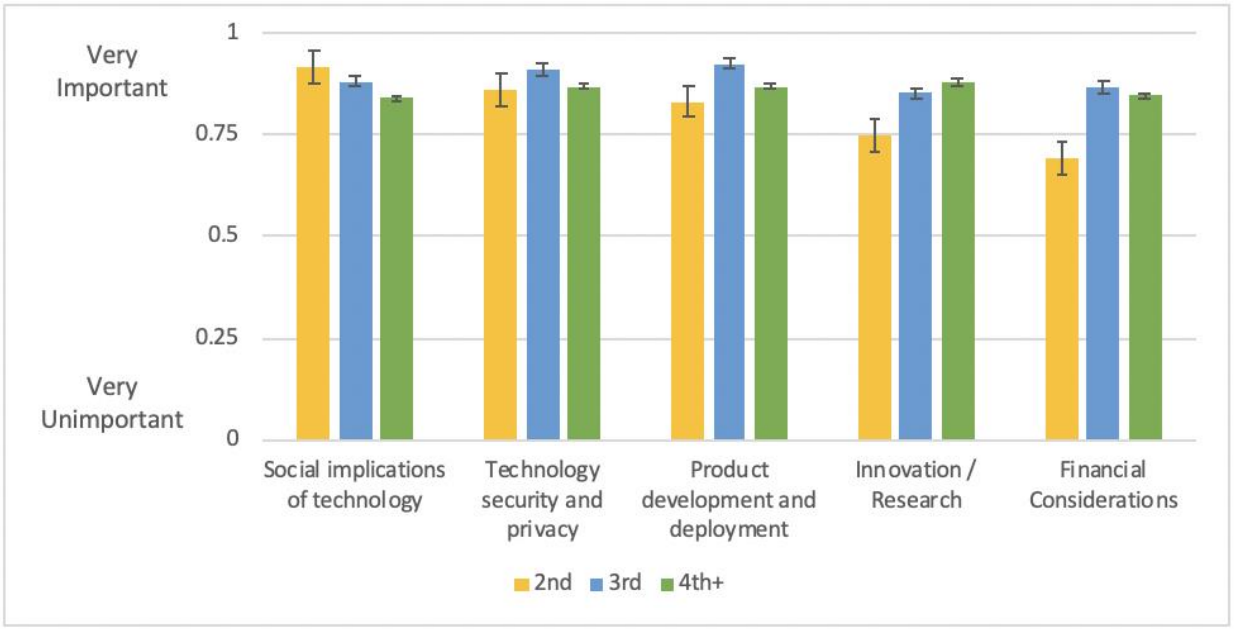

Figure 7: Factors important to one's future career for computing students at different years in their respective degrees. Note: Each bar represents the mean value on that measure for each grade. Means were scaled to a 0 to 1 range ([mean - 1]/5).

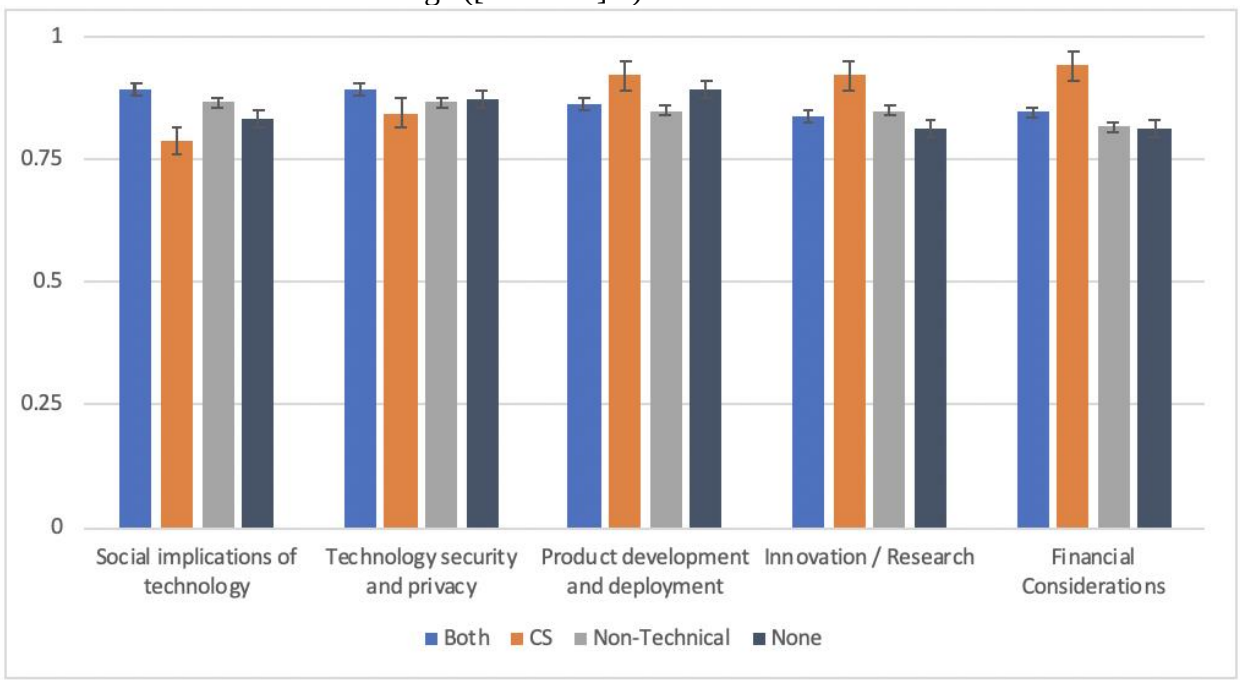

Figure 8: Factors important to one's future career for computing students with differing relevant coursework. Note: Each bar represents the mean value on that measure for each coursework. Means were scaled to a 0 to 1 range ([mean - 1]/5).

Overall, the results of personal opinions of factors from global citizenship and importance to future careers did not appear to be influenced by the number of years a student has been in the

program or types of classes they have taken. Though Cal Poly has impacted students understanding of how social responsibility and ethics are important to computing professionals overall, there is work to be done to further emphasize that social responsibility and ethics are relevant to each student personally and professionally.

Future Work

Computing Department Suggestions

This research has shown that the computing departments may want to focus on inviting students to consider and understand how their own technical work and future careers will interface with society, requiring considerations of ethics and social responsibility in design. As a student there are a few ways I can personally speak to that can make discussions and lessons in technical classes more effective. Firstly, having strong examples or case studies that discuss real companies or failures to highlight that these problems are actually happening. Discussing consequences abstractly is less effective. Additionally, when ethics and social responsibility in computing comes up in lecture, taking a bit of time to allow for discussion between students and allows them to consider how they personally feel about these topics. These are not new educational techniques, but in technical classes peer discussions happen far less. Some classes already do this, and I believe it encourages students to consider the lesson more thoughtfully.

Another way to increase personal application of ethics and social responsibility in technical work is to collaborate with other departments such as Liberal Arts and Engineering Studies or Philosophy. In the Computer Science department meeting, Dr. Peterson suggested working with

the Philosophy department to add an ethical consultation within senior projects. This would be a great way to facilitate making ethics and social responsibly a part of the design process.

Lastly, I have noticed that there are a few different ethics and social responsibility related endeavors at Cal Poly. I have been personally interested in computing ethics since coming to Cal Poly, and every time I heard about these projects, I was surprised I had not heard about them earlier. The Institute for Advanced Technology and Public Policy has had computer science student researchers but does not appear to be well known from my perspective. The Ethics + Emerging Sciences Group has a Technology, Policy & Ethics Lecture Series, but their most recent talk was not in either department newsletter. Finally, there is Ethical Tech @ Cal Poly, which has a podcast and was awarded a grant last year to more or less research ways to "solve" the problem discussed in this paper of making sure students going into tech are equipped with the right beliefs, values, and tools to be ethical engineers. This group aims to introduce interdisciplinary classes and start an ethical symposium among other projects. This group has large goals that will take many years to accomplish, and a great way to start is by making CS, SE, and CPE aware that initiatives like this are taking place at Cal Poly. I personally became aware of it while doing research for my senior project. Though not every computing student will engage with these groups, increasing awareness demonstrates that these are important initiatives within our departments.

Furthering this Work

Building off of this work would most likely include re-doing Cech's work by surveying the same cohort as freshman and seniors at Cal Poly. This would give an even more accurate representation of how effective our curriculum is. The types of questions could also be more varied. It would be interesting to see what students ranked as most to least threatening of different ethical problems in technology or including a free response question asking students to list some of the most threatening problems, they think the technology industry faces. Other interesting questions could be how important a relevant social responsibility or ethical consideration is to different sub-fields within computing like artificial intelligence or security. Lastly, it would be interesting to do interviews with a sample of students to see to what extent they consider ethics and social responsibility relevant to their personal lives and future careers.

Reflections

This work felt very worthwhile and meaningful to pursue. I was able to research and learn about computer science ethics education and collect data from students that have meaningful results to the department. Becoming an even more educated and ethically conscious engineer has been a goal of mine within my degree, and I am incredibly grateful that my senior project has contributed to this.

The work achieved in this project successfully demonstrates that Cal Poly has had a positive impact on the social responsibility and public welfare beliefs of Cal Poly students. Dr. Cech's research called for university curriculums to put in the work to re-engage students and educate engineers that do not prioritize meritocracy and understand the importance of society and ethics within technology design and innovation. I believe that Cal Poly is taking the steps to fix this problem and for that I am proud.

Overall, the project could be improved in a variety of ways. The statistical analysis of this study could be improved and actually use the same analysis present in Dr. Cech's work. There could have also been a bigger push to survey more than 71 students, with a growing department it should be feasible to get more than 200 students to respond to a survey of this size.

I believe that the biggest takeaway from this project is that Cal Poly has implemented some very effective measures to help students become more ethically conscious and socially responsible. These efforts have an impact and that should be motivating to continue to improve and expand opportunities for computing students to confront and consider these values in their education. From continuing to discuss these values in technical classes to working with the Ethical Tech @ Cal Poly initiative to implement new solutions, there are lots of ways to develop ethical and socially responsible values in Cal Poly computing students.

Bibliography

[1] J. Orlowski, Director, *The Social Dilemma.* [Film]. USA/: Exposure Labs; Argent Pictures; The Space Program, 2020.

[2] S. Zuboff, "Opinion | You Are Now Remotely Controlled," New York Times, New York City, 2020.

[3] N. Turner Lee, P. Resnick and G. Barton, "Algorithmic bias detection and mitigation: Best practices and policies to reduce consumer harms," 22 May 2019. [Online]. Available: https://www.brookings.edu/research/algorithmic-bias-detection-and-mitigation-best-practices-and-policies-to-reduce-consumer-harms/. [Accessed 1 June 2022].

[4] C. Corbett and C. Hill, "Solving the Equation," AAUW, Washington DC, 2015.

[5] California Polytechic State University, San Luis Obispo, "BS Computer Science," [Online]. Available: https://catalog.calpoly.edu/collegesandprograms/collegeofengineering/computersciencesoftwareengineering/bscomputerscience/. [Accessed 1 June 2022].

[6] E. Cech, "Culture of Disengagement in Engineering Education?," *Science, Technology, & Human Values,* vol. 39, no. 1, pp. 42-72, 2014.

[7] Q. Zhu, A. Gammon, R. F. Clancy, A. Angeli, S. Streiner and R. Thorpe, "Exploring the Ethical Perceptions of First Year Engineering Students: Public Welfare Beliefs, Ethical Behavior, and Professional Values," American Society for Engineering Education, Washington D.C., 2022.

[8] A.-M. Núñez, M. J. Mayhew, M. Shaheen and L. S. Dahl, "Let's Teach Computer Science Majors to Be Good Citizens. The Whole World Depends on It.," EdSurge, Portland, 2021.

[9] I. Stavrakakis, D. Gordon, B. Tierney and A. Becevel, "The teaching of computer ethics on computer science and related degree programmes. a European survey," *International Journal of Ethics Education,* vol. 7, p. 101–129, 2022.

[10] L. Cohen, H. Triedman, H. Precel and K. Fisler, "A New Model forWeaving Responsible Computing Into Courses Across the CS Curriculum," in *Special Interest Group Computer Science Education,* Virtual Event, 2021.

[11] R. Reich, M. Sahami, J. M. Weinstein and H. Cohen, "Teaching Computer Ethics: A Deeply Multidisciplinary Approach," in *Special Interest Group Computer Science Education,* Portland, 2020.

[12] B. J. Grosz, D. Gray Grant, K. Vredenburgh, J. Behrends, L. Hu, A. Simmons and J. Waldo, "Embedded EthiCS: Integrating Ethics Broadly Across Computer Science Education," *Communications of the ACM,* vol. 62, no. 8, pp. 54-61, 2019.

[13] R. Ferreira and M. Y. Vardi, "Deep Tech Ethics: An Approach to Teaching Social Justice in Computer Scienc," in *Special Interest Group Computer Science Education*, Virtual Event, 2021.

[14] C. M. Gray, K. Melkey, S. S. Chivukula and R. Manocha, "Understanding "Dark" Design Roles in Computing Education," in *International Computing Education Research*, Virtual Event, 2021.

[15] N. Young and S. Krishnamurthi, "Early Post-Secondary Student Performance of Adversarial Thinking," in *International Computing Education Research,* Virtual Event, 2021.

[16] C. Fiesler, N. Garrett and N. Beard, "What Do We Teach When We Teach Tech Ethics?: A Syllabi Analysis," in *Proceedings of the 51st ACM Technical Symposium on Computer Science Education,* Portland, 2020.

Appendices

Appendix A: Survey

Survey Pt. 1

Background Questions

2. What is your school year?

- 1st year
- 2nd year
- 3rd year
- 4th+ year

3. What is your major?

- Computer Science
- Computer Engineering
- Software Engineering
- Other

3. What is your major?

- Computer Science
- Computer Engineering
- Software Engineering
- Other

4. What is your gender identity?

- Female
- Male
- Non-binary

5. Have you taken any of the following classes?

	Yes	No
CSC 300 Professional Responsibilities	○	○
PHIL 323 Ethics, Science, and Technology	○	○
DATA 401 Data Science Process and Ethics	○	○
CSC 490 C++ and Social Justice	○	○
CSC 321 Intro to Computer Security	○	○
DATA 301 Intro to Data Science	○	○
CSC 480 Artificial Intelligence	○	○
CSC 466 Knowledge Discovery from Data	○	○
CSC 487 Deep Learning	○	○
ES 350 Gender, Race, Culture, Science & Technology	○	○
ES 351 Gender, Race, Class, Nation in Global Engineering Development	○	○

6. Please list any other Philosophy (PHIL), Ethnic Studies (ES), Political Science (POLS), or other classes that are similar to the above classes that you have taken.

Enter your answer

7. How much do you agree with the following statements at this point in your life?

	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly agree
I am actively working to foster justice in the world.	○	○	○	○	○	○	○
I frequently think about the global problems of our time and how I will contribute to resolving them.	○	○	○	○	○	○	○
I am currently taking steps to improve the lives of people around the world.	○	○	○	○	○	○	○
I am actively learning about people across the globe who have different religious and cultural ways of life than I do.	○	○	○	○	○	○	○

8. What, in your opinion, makes a successful career?

	Very Unimportant	Somewhat Unimportant	Neither Important nor Unimportant	Somewhat Important	Very Important
Professional and ethical responsibilities	○	○	○	○	○
Understanding the consequences of technology	○	○	○	○	○
Understanding how people use machines	○	○	○	○	○

9. Please indicate the personal importance to you of:

	Very Unimportant	Somewhat Unimportant	Neither Important nor Unimportant	Somewhat Important	Very Important
Improving society	○	○	○	○	○
Promoting racial equality	○	○	○	○	○
Helping others in need	○	○	○	○	○
Technology being used to positively impact society	○	○	○	○	○

10. Please indicate the importance to your major's department of:

	Very Unimportant	Somewhat Unimportant	Somewhat Important	Very Important
Ethical and/or social issues	○	○	○	○
Policy indications of engineering	○	○	○	○
Broad education in humanities and social sciences	○	○	○	○
Writing skills	○	○	○	○
Basic research	○	○	○	○
Background in math and science	○	○	○	○
Innovation	○	○	○	○
Advancement of scientific knowledge	○	○	○	○
Invention	○	○	○	○

11. Please indicate the perceived importance to your future (not-job specific) career of:

	Very Unimportant	Somewhat Unimportant	Somewhat Important	Very Important
Social implications of technology	○	○	○	○
Technology security and privacy	○	○	○	○
Product development and deployment	○	○	○	○
Innovation / Research	○	○	○	○
Financial Considerations	○	○	○	○

Appendix B: Processed Data Table – Mean and SD

Question	Prompt	Subset	Mean	Standard Deviation
Public Welfare Beliefs	Professional/ethical responsibilities (1-very unimportant to 5-very important)	--	4.578	0.601
		2nd year	4.333	0.866
		3rd year	4.647	0.606
		4th + year	4.614	0.538
		Taken both types of classes	4.677	0.475
		CS classes	4.692	0.480
		Non-Technical classes	4.6	0.633
		No Relevant classes	4.167	0.835
	Understanding consequences of technology (1-very unimportant to 5-very important)	--	4.633	0.591
		2nd year	4.111	0.601
		3rd year	4.764	0.437
		4th + year	4.704	0.594
		Taken both types of classes	4.710	0.631
		CS classes	4.692	0.480
		Non-Technical classes	4.533	0.640
		No Relevant classes	4.500	0.522
	Understanding how people use machines (0-very unimportant to 5-very important)	--	4.856	0.552
		2nd year	4.555	0.527
		3rd year	4.529	0.624
		4th + year	4.627	0.536
		Taken both types of classes	4.600	0.479
		CS classes	4.462	0.660
		Non-Technical classes	4.667	0.640
		No Relevant classes	4.583	0.515
	Social Consciousness Scale (1-very unimportant to 5-very important)	--	4.536	0.486
		2nd year	4.741	0.365
		3rd year	4.490	0.502
		4th + year	4.523	0.500
		Taken both types of classes	4.485	0.523
		CS classes	4.462	0.570
		Non-Technical classes	4.667	0.388
		No Relevant classes	4.583	0.430
	Technology being used to positively impact society (1-very unimportant to 5-very important)	--	4.761	0.430
		2nd year	5.000	0.000
		3rd year	4.765	0.437
		4th + year	4.727	0.451
		Taken both types of classes	4.806	0.425
		CS classes	4.615	0.506

		Non-Technical classes	4.8	0.352
		No Relevant classes	4.75	0.452
Departmental Cultural Emphases Measures (1-very unimportant to 4-very important)	Math and Sci	--	3.576	0.577
	Innovation	--	3.437	0.691
	Sci Advancement	--	3.352	0.635
	Invention	--	3.352	0.699
	Ethical/social issues	--	3.056	0.8765
	Basic research	--	2.958	0.764
	Policy indications	--	2.829	0.798
	Gen education	--	2.745	0.967
	Writing skills	--	2.657	0.883
Global Citizenship, agreeing with statements at this point in your life (1-Strongly Disagree to 7-Strongly Agree)	Global Citizenship Score (average)	--	5.039	1.031
		2nd year	4.833	0.901
		3rd year	4.882	1.012
		4th + year	5.153	1.077
		Taken both types of classes	5.056	1.024
		CS classes	5.096	0.9765
		Non-Technical classes	5.367	0.968
		No Relevant classes	4.521	1.099
Future Career Emphases (1-Very Unimportant to 4-Very Important	Social Implications of Technology	--	3.437	0.712
		2nd year	3.667	0.5
		3rd year	3.530	0.515
		4th + year	3.364	0.810
		Taken both types of classes	3.581	0.624
		CS classes	3.154	1.068
		Non-Technical classes	3.467	0.516
		No Relevant classes	3.333	0.651
	Technology Privacy and Security	--	3.507	0.714
		2nd year	3.444	0.527
		3rd year	3.647	0.606
		4th + year	3.477	0.792
		Taken both types of classes	3.581	0.672
		CS classes	3.385	0.961
		Non-Technical classes	3.467	0.640
		No Relevant classes	3.5	0.674
	Product Development and Deployment	--	3.507	0.630
		2nd year	3.333	0.707
		3rd year	3.706	0.470
		4th + year	3.477	0.664
		Taken both types of classes	3.452	0.626
		CS classes	3.692	0.480
		Non-Technical classes	3.400	0.724
		No Relevant classes	3.583	0.669

	Innovation / Research	--	3.423	0.647
		2nd year	3.000	0.707
		3rd year	3.412	0.618
		4th + year	3.523	0.628
		Taken both types of classes	3.355	0.615
		CS classes	3.692	0.439
		Non-Technical classes	3.400	0.815
		No Relevant classes	3.250	0.622
	Financial Considerations	--	3.324	0.671
		2nd year	2.778	0.833
		3rd year	3.471	0.515
		4th + year	3.386	0.655
		Taken both types of classes	3.387	0.568
		CS classes	3.769	0.751
		Non-Technical classes	3.267	0.743
		No Relevant classes	3.25	0.754