# A Student-Led Ethics Deep Dive, Discussion, and Content-Generation Ethics Assignment in Computer Science & Engineering Capstone

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## Abstract

As senior capstone design represents the culmination of the knowledge and understanding gained throughout the four-year degree program, it has significant prominence in ensuring that we graduate ethical and professional engineers. We implemented a content generation assignment in two sections of a senior computer science and engineering (CSCE) capstone course. In these two sections, 49 students were asked how interactive ethics assignments helped them become knowledgeable about ethical issues, analyze the ethical implications of their projects, and the value of choosing their own ethics topics. Students in both sections on average rated the ethics assignments highly for learning ethics issues and being able to choose topics, with more mixed ratings of the ability to analyze their own capstone projects. From written responses, we found that students valued assignments for bringing awareness of relevant ethical issues in society, for providing opportunities to learn with and from peers, and for deeper learning of ethics principles to be applied to their specific projects. Our results are useful for instructors who wish to incorporate ethics into their CSCE courses while also supporting student engagement, autonomy, and peer learning.


## Introduction

Ethics has been part of the ABET required outcomes since 2004 [1]. Computer science and engineering (CSCE) students after completing their senior capstone are expected to possess “an ability to understand ethical and professional responsibilities and the impact of technical and/or scientific solutions in global, economic, environmental, and societal contexts” through a variety of curriculum content and enhancements [1].

In the Computer Science and Engineering Department at [Blinded] University, a large R1 Southwestern university, the ethics-based content and assignments include one or more of the following: an analysis and explanation of the ethical implications of their project in their final report and in various presentations to stakeholders, listening to a lecture on the ethics topic, receiving external feedback on their ethical analyses from an external panel, or viewing asynchronously standard ethics modules created by the college.

In regards to the standard ethics modules created by the college, instructors of both the seminar and capstone classes are encouraged to require completion of these modules to introduce the ethics topics in their respective classes. These ethics modules were designed to introduce issues

that have negatively impacted the ethical perception of the computer science and engineering industry. Topics include ethical issues in space, security, and facial recognition. After the completion of the modules, instructors can ask students about what they thought about the modules and what they learned, although this was not applied consistently in all classes. For those classes that collected feedback, students were generally positive about the module content, however the majority of students had already viewed the modules as many as four times across three different courses. The same assessments were also given which evaluated students' grasp of ethics in general, but not how it was applicable to their group project.

In regards to students' explanation of the ethical implications of their project, some teams are asked to participate in ABET reviews conducted by industry representatives, where several reviewers have commented on students' superficial understanding of the ethics implications of their project. For example, projects that use open source software were not able to articulate the importance of giving credit to the author of the original code base and the corresponding ethical consequences of such actions.

While all of these pedagogy approaches used in increasing awareness of ethics in CSCE provided some benefit, students continue to show a lack of sufficient understanding of ethical implications in their group project in their final report and presentations to various stakeholders.

The situation of overuse of the college ethics modules and superficiality of the corresponding assessment raised the question of why CSCE faculty relied on these standard modules, instead of generating their own ethics content that is unique to their class. After informal discussions with students, the authors surmised that faculty may be afraid of misrepresenting ethical issues, especially as state laws were starting to be enacted to restrict the discussion of topics that might be misconstrued as supporting DEI. In addition, some instructors may not have the time to fully understand the state laws and requirements of DEI and other topics related to ethics.

Given that the standalone ethics course was no longer being offered, and the inconsistency with which ethics was taught in the different courses, the authors wanted to experiment with a novel approach for our students to address the need for students to understand ethics at a deeper level, especially how it impacts their particular project. In addition, students confirmed that the standard ethics modules were not sufficient to understand ethical issues, and ethical implications of their group project, leaving them at a disadvantage as compared to their peers who graduated from different educational institutions.

In response to this need of students to understand the ethical implications of their group project, one of the authors of this paper who also taught capstone piloted an approach for imparting ethics in her classroom in Fall 2022, which involved student teams creating a video of ethical implications of their project, with the goal of sharing this with other courses in the CSCE curriculum. The approach was enhanced and continued to Spring 2023, Fall 2023, and is

currently planned to be deployed this Spring 2024 in capstone classes taught by other faculty. The approach had two objectives:

1) Allow the capstone students to explore at a deeper level ethical topics of interest to them and which impacted their project. This created a more authentic process for an ethics discussion in the senior capstone design class.

2) Create additional content, in the form of videos on various ethics topics that are relevant to CSCE undergraduate students, to be shared to other instructors teaching other CSCE courses in the curriculum.

Although the specific approaches used by the other capstone instructors differed, they were motivated by the objective above. The approach piloted in Fall 2022 is described next.

Students were first asked to pick one recent news story related to the CSCE field that exposes an ethical issue. The team explored the issue and were asked to prepare a 20-minute class discussion on the news story and related ethical concerns. Thereafter, the presenting team incorporated what they learned from the class discussion to create a short video that can be used in future course offerings or other courses in the CSCE curriculum.

The assignment for the 20-minute ethics discussion required the student teams to avoid conducting a standard presentation, and instead required them to design an interactive presentation, using the following format:

1. [3-5 min] Introduce your topic/issue engagingly (e.g., video, skit, polling, storytelling, rap)
2. [7-9 min] Lead a small group activity for the other teams in class to independently explore the given topic/issue in more depth. Select one of the following small group activities:
    a. Mock Trial: A sample scenario involving a company being put on trial for an ethical-related issue. Specific teams are asked to play the role of prosecutor, while some play the role of defense. The prosecutor and defense teams prepare a set of arguments and counter-arguments. The remaining students in the class play the role of judge and jury.
    b. Internal Company Debate: A scenario involving a company considering adopting a new technology that is impacted by the particular ethics topic (e.g., ethics of using open-source software in a product intended for commercialization). Specific teams are asked to represent “adoption,” while some teams are asked to oppose adoption. The “adoption” and “oppose adoption” teams create a list of reasons to

support their position. The rest of the class play the role of upper management, tasked with making the final adoption decision.

c. Question Exploration: Identify several questions to explore related to the presented ethical topic/issue. Each team creates answers with supporting justification. Teams can all be assigned the same questions or different questions per team. Afterwards, a moderator facilitates a discussion with all teams to synthesize answers.
d. Other student-proposed activities not covered in the previous items, for approval by the instructor and TA prior to the actual in-class activity.

3. Instructor team leads the entire class in a discussion to recap what students learned about the ethical topics/issue. The structure of this class discussion will depend on the small group activities selected.

Given the initial success of this novel approach based on informal student feedback, this paper seeks to validate the utility of the approach by collecting and analyzing data which address the research questions (RQ) below.

RQ1: How did the interactive student-led sessions impact students' learning of current ethical issues in computing and relate these issues to their capstone project?

RQ2: What was the effect in students' learning in allowing them to select their own ethics topic for the interactive student-led sessions?

# Literature Review

## Ethics Education in Computer Science Courses

The ethics segment of the capstone course is primarily motivated by a requirement set forth by ABET, which requires each accredited institution to produce graduates that have knowledge of ethics in the science and engineering realm [2]. The 2023-2024 ABET criteria listing for computing programs includes the following requirement: "An ability to understand ethical and professional responsibilities and the impact of technical and/or scientific solutions in global, economic, environmental, and societal contexts." Ethics has been part of the ABET required outcomes since 2004, with the 2019-2020 criteria including ethics into Criterion 5; Curriculum: "The curriculum must combine technical, professional and general education components in support of student outcomes." and "The discipline specific content of the curriculum must focus on the applied aspects of science and engineering and must E. Include topics related to professional responsibilities, ethical responsibilities, respect for diversity, and quality and continuous improvement [1]."

Ethics instruction for undergraduate computer science and computer engineering courses is an important topic in computing education research. A recent systematic review of 100 studies showed that ethics is commonly taught in both stand-alone ethics courses and technical computing courses with pedagogy such as readings, lectures, and discussions [3]. The two most common methods of integration were a stand-alone course and multiple course modules, with just over half of collected studies describing some type of assessment [3]. In-class activities in CSCE courses have been used to evaluate ethical issues as an entire class, along with individual activities for writing and reflection, to enhance deeper student engagement in complex ethical issues in society and their tradeoffs [4]. Ethics modules with in-class lectures, group activities, and writing assignments reflecting on stakeholder tradeoffs which are embedded into course learning have contributed to increased interest in technology-based ethical issues and self-efficacy for learning about them in the modules [5]. However, incorporating ethics education into CSCE courses is challenging for computing professors due to low confidence and competence, difficulty integrating content with existing curriculum, and a lack of resources, collaboration, and professional community to support teaching ethics [6].

## Student-Led Teaching and Learning Ethics

Peer teaching as a pedagogy places students at the center of instruction and makes them responsible for learning as a group, as based on Vygotsky's theory of social constructivism [7]. In capstone learning, student agency supports the ability to make decisions during design, especially during problem framing [8]. Agency is also essential for students in defining and making meaning of their personal identities, experiences, and narratives as engineers [9]. Therefore, we examine the role of agency Student-led discussions have value for collaborative learning and reflection of ethics. In a systematic review of peer teaching in healthcare education, both direct and indirect peer-based teaching methods were identified including student-led lectures, feedback, and problem-based learning [10]. However, few studies have focused on peer learning as an instructional method for computing ethics education. In a longitudinal study of first-year computer science course which included lectures and case studies on responsible computing and social justice values, students who participated in a think-talk-share peer learning model were able to identify intersecting ethical challenges in responsibility, bias, and mechanisms of unfairness, and valued their learning with peers for developing ideas [11]. Collaboratively developing a code of ethics among engineering, computing, and non-engineering disciplines through group discussions and case studies can engage students in connecting philosophy with engineering [12]. Beyond instructor-led ethics modules and lectures, there is potential for students to engage in peer teaching when learning ethical issues.

# Research Methods

To answer the research questions, we used a multi-method research design consisting of both quantitative and qualitative approaches. Details on the approach are covered in the following sections.

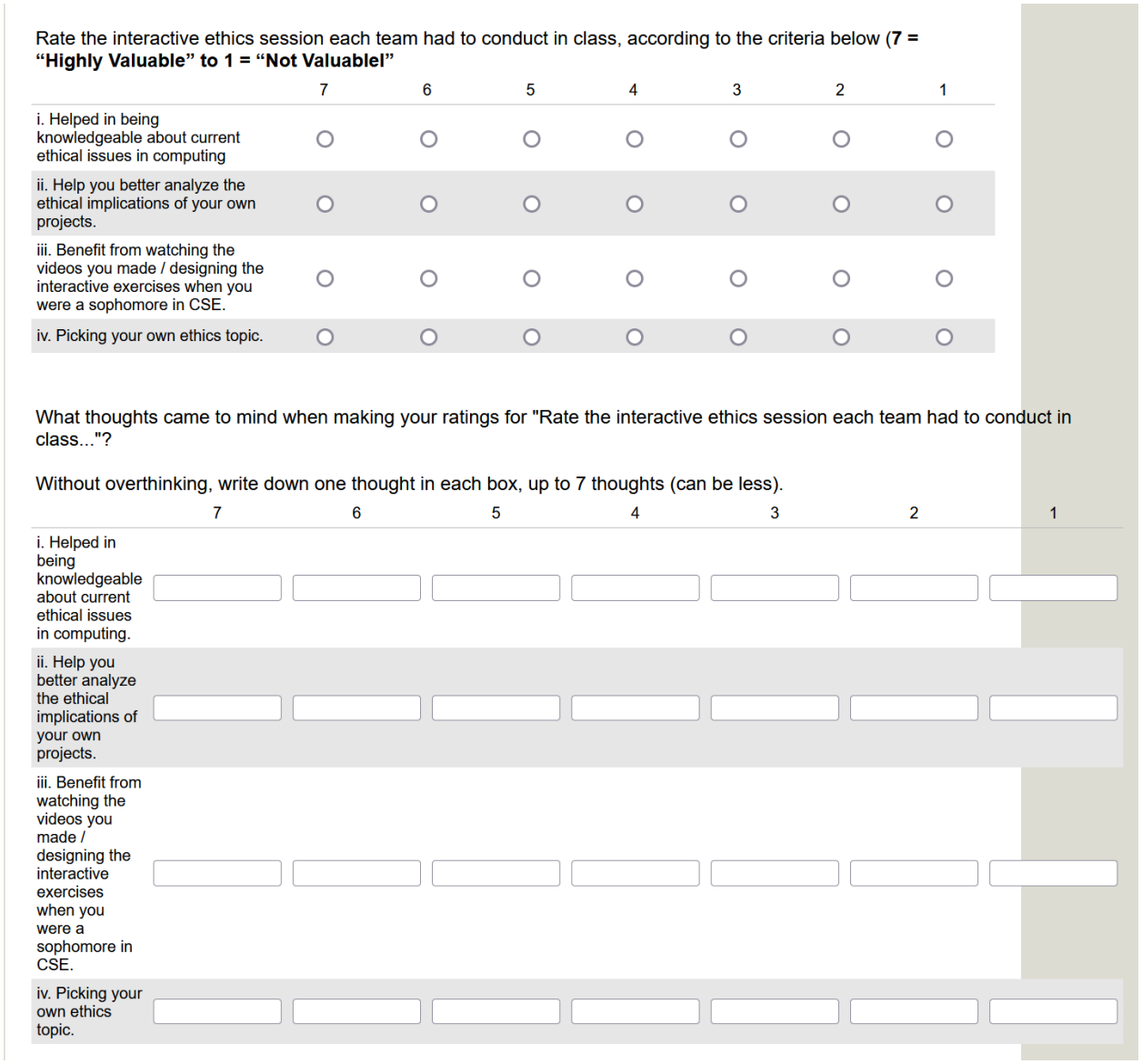
## Site and Participants

The participants were 49 full-time students, at the senior level, from three sections of an undergraduate Senior Capstone Design course in the Computer Science and Engineering Department at [Blinded] University, a large R1 Southwestern university. The capstone course focuses on teaching an engineering approach to developing a computing solution to a multi-disciplinary problem, through a group project. Students are primarily asked to express interest in the list of possible projects presented, then the instructor uses specific criteria to finalize team placement. Alternatively, students can propose a project idea for review and approval of the instructor. The approach to assigning students to teams varies across the different capstone sections.

The survey was conducted as part of a class assignment deployed towards the end of the semester, which involved a quantitative component that consists of several questions asking students to select from a list of options based on the Likert scale. Thereafter, students are asked to provide a rationale for their answer via a text-based response. The survey instrument is described in the next section.

## Survey Instrument

The quantitative approach used a non-experimental correlational study [13], involving gathering student perceptions of the value of the interactive student-led sessions, where students respond on a 7-point scale (1 = “Not valuable at all” to 7 = “Highly valuable). The full survey instrument as it was administered on the Qualtrics survey platform is shown in Figure 1.



Rate the interactive ethics session each team had to conduct in class, according to the criteria below (**7 = "Highly Valuable" to 1 = "Not Valuable"**

| | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|
| i. Helped in being knowledgeable about current ethical issues in computing | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| ii. Help you better analyze the ethical implications of your own projects. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| iii. Benefit from watching the videos you made / designing the interactive exercises when you were a sophomore in CSE. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| iv. Picking your own ethics topic. | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

What thoughts came to mind when making your ratings for "Rate the interactive ethics session each team had to conduct in class..."?

Without overthinking, write down one thought in each box, up to 7 thoughts (can be less).

| | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|
| i. Helped in being knowledgeable about current ethical issues in computing. | | | | | | | |
| ii. Help you better analyze the ethical implications of your own projects. | | | | | | | |
| iii. Benefit from watching the videos you made / designing the interactive exercises when you were a sophomore in CSE. | | | | | | | |
| iv. Picking your own ethics topic. | | | | | | | |

Figure 1. Survey items for student ratings and reflections of interactive ethics assignments.

The survey is based on the Bandura's general self-efficacy scale and was validated for use in measuring self-efficacy in engineering design by Carberry and colleagues [13]. The survey involved students choosing a value from 1 to 7. An individual who perceives that the approach is of high value to learning ethics, was able to increase their understanding of ethical issues in CSCE. Likewise, it helped students understand ethical implications in their group project [15].

A high rating for the task value (i.e., 6,7) indicated that the respondent perceived that the student-led ethical discussions helped them understand ethics better, which they feel will contribute to success in their professional endeavors. Similarly, a low rating for the task value (i.e., 1,2) indicated that the respondent perceives the student-led ethical discussions as a task that

is not useful in contributing to their current understanding of ethics. Respondents who gave ratings of 3,4, or 5 viewed the discussions as somewhat valuable or somewhat not valuable.

The survey results were interpreted similarly using the techniques described by Carberry and colleagues [13, 14].

To validate the quantitative survey results, a qualitative approach was added which involved asking students to provide reasons for their ratings, especially if their rating is below a 4. In addition, students were asked to share their thoughts of why they chose the particular rating.

The qualitative surveys were designed using the "thought listing" technique [15, 16], a qualitative research approach. It involves an individual noting down thoughts and ideas on a specific topic as they come to mind, without any specific structure, which is then analyzed for trends or patterns.

# Data Collection and Preparation Procedures

The surveys were administered during the 15th week of the semester. Prior to the administration of the surveys, members of the teaching team described the purpose of the survey and the mechanics of filling out the survey. Surveys were filled out during the lab. To avoid bias, one of the authors who did not teach a capstone class took the lead in the subsequent analysis of the data, which was anonymized, with no personally identifiable information (PII). The data was collected as part of a class assignment with a retrospective IRB in process of submission.

# Data Analysis

We analyzed the mean and standard deviations of students' ratings for each of the quantitative survey questions. Thereafter, we performed thematic analysis on the written responses, as described below.

## Thematic Analysis

Qualitative data gathered, consisting of students' perception of the value of the interactive student-led sessions, were analyzed using the thematic approach to uncover trends and patterns. Thematic analysis is a method for identifying, analyzing, and reporting patterns (i.e., themes) within qualitative data. It is widely used in various fields such as psychology, sociology, and organizational research [16].

In this study, thematic analysis was performed inductively, where codes and themes were derived directly from the data. The steps used for thematic analysis consisted of generating initial codes after the authors became familiar with the responses. All but one of the authors were instructors

of the course sections, hence the author not teaching the course took the lead in coding. Codes were used to label interesting, unique, and relevant information or direct quotes. Thereafter the author who took the lead in coding, presented initial codes to the other authors, also capstone instructors, to validate assumptions in coding. All authors reviewed and discussed codes and themes to achieve consensus. Codes were then categorized into potential themes by looking for patterns of meaning or similarity. The potential themes were again reviewed by all authors to check assumptions [15].

Thereafter, themes were further refined as necessary after reviewing again the coded extracts and the entire data set, to ensure that the themes accurately represented the data and are aligned with the RQs. Each theme was given a meaningful name and clearly defined, including what data was represented in a particular theme. For transparency and to maintain inter-coder reliability, assumptions behind the coding process (e.g., mapping of data to code to themes) were shared among the authors [17]. Inter-coder reliability is an approach used to ensure all participants in the analysis process have a consistent understanding of the thematic analysis process used [17]. Lastly, results were generated as a result of analyzing the themes, incorporating quotes or examples from the data to support each theme [17].

## Results and Discussion

### Quantitative Ratings of Ethics Assignment Learning Benefits

Overall, students rated the benefits of learning from the ethics assignments highly on average. Table 1 contains average ratings for ethics assignments in each section and for both sections combined.

Table 1. Average ratings for ethics assignments' impact to students' learning by instructor sections.

| | 1. Helped in being knowledgeable about current ethical issues in computing | | 2. Help you better analyze the ethical implications of your own projects. | | 3. Benefit from watching the videos you made / designing the interactive exercises when you were a sophomore in CSE. | | 4. Picking your own ethics topic. | |
|---|---|---|---|---|---|---|---|---|
| **Section** | **M** | **SD** | **M** | **SD** | **M** | **SD** | **M** | **SD** |
| Both (n=49) | 5.9592 | 1.2741 | 5.4694 | 1.6086 | 5.2245 | 1.7709 | 6.1633 | 1.1429 |
| Instructor 1 (n=24) | 5.7500 | 1.3593 | 4.7917 | 1.6413 | 4.8750 | 1.5126 | 5.9583 | 1.3015 |
| Instructor 2 (n=25) | 6.1600 | 1.1790 | 6.1200 | 1.3013 | 5.5600 | 1.9596 | 6.3600 | 0.9522 |

Across both sections, students rated choosing their own ethics topics most highly (M = 6.16, SD = 1.14) as well within each section (Instructor 1: M = 5.96, SD = 1.30; Instructor 2: M = 6.36, SD = 0.95). The widest difference in ratings between sections was for the assignments' help in analyzing ethical implications of capstone projects (Instructor 1: M = 4.79, SD = 1.64; Instructor 2: M = 6.12, SD = 1.30). On average for both sections, students' lowest ratings were for the benefits that videos would have had during their sophomore year (M = 5.22, SD = 1.77).

Figure 1 shows the distribution of student ratings for each question in the survey. Distributions for Questions 1, 2, and 4 were negatively skewed as students rated these aspects highly. For both sections, distributions were similar for Question 1, "Helped in being knowledgeable about current ethical issues in computing" and Question 4, "Picking your own ethics topics." Instructor 2's section gave higher ratings to the importance of analyzing ethical implications of capstone projects. The two sections were somewhat opposite in rating Question 3, as Instructor 1's section gave most ratings a 4, and Instructor 2's students mostly rated it as an 8.

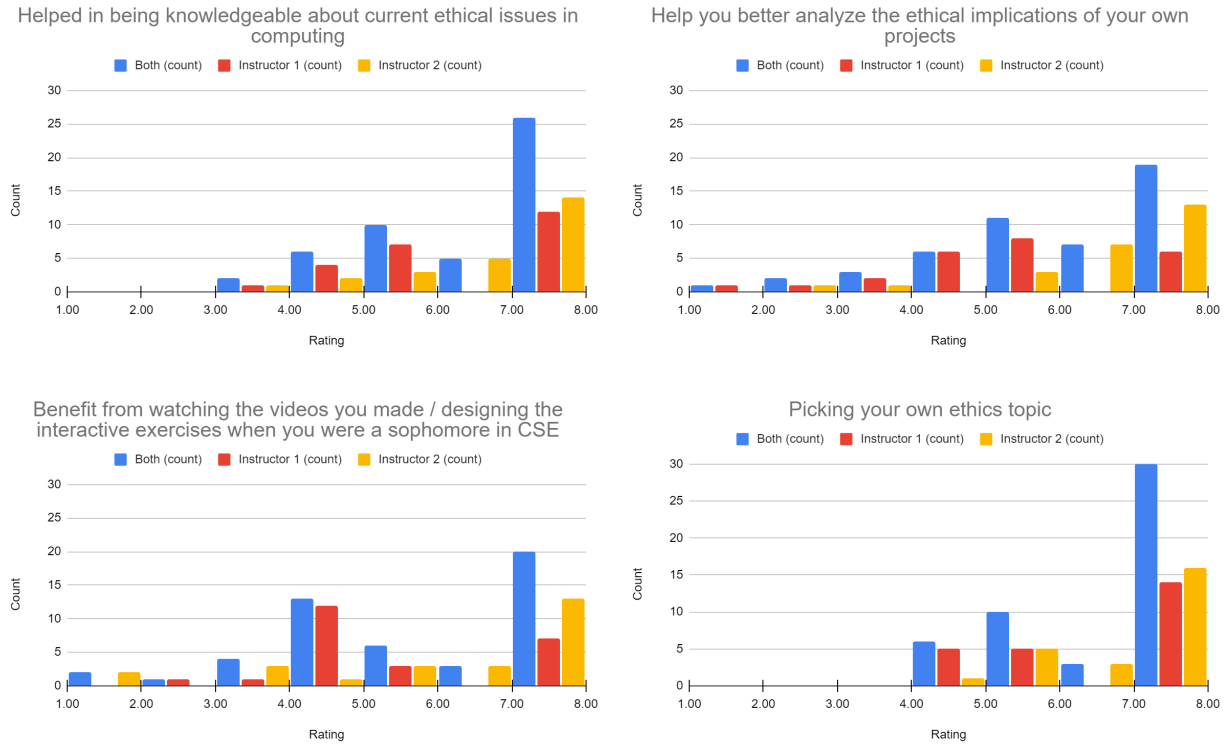



Figure 2. Histograms of student ratings of ethics assignments' impact to students' learning.

Because most responses to Question 3 were the result of students either not remembering making videos or not understanding the question, this produced differences in ratings between the two sections. Therefore, the researchers decided to remove this question from further thematic analysis as it could not be meaningfully interpreted.

# Thematic Analysis Results

## Support for students being knowledgeable of current ethical issues in computing

Table 2 contains developed codes and descriptions for Question 1, "Helped in being knowledgeable about current ethical issues in computing."

Table 2. Question 1 Codes and Descriptions.

| **Code** | **Description** |
|---|---|
| Awareness of issues | Realization of current societal issues in ethics |

| | |
|---|---|
| New insights | Reflections on new ethics issues |
| Increased understanding | Deeper learning of the variety of topics in ethics and their impact |
| Different perspectives | Learning about ethical issues from many perspectives |
| Engaging learning | Interest in material through peer learning |
| Mixed response | Positive and negative feedback of the assignment |
| Positive | General comments on enjoying assignments |

In the first code *Awareness of issues*, students described their learning of ethical challenges which they had not previously considered. For example, one student said "There were some ethical concerns I hadn't even fathomed, so it was cool to see." Another said "I didn't know about the rampant concerns of copyright in AI image generation prior to this project." Others said "I learned about issues like sustainability, political concerns," and "Kept me informed on ethical issues I wasn't aware of; helped me understand the ethical dilemmas large-scale developers face."

*New insights* showed students' learning of new ethical topics. One student said "Gained insights into real-world ethical dilemmas," and another said "There were presentations that surprised me as things I had never thought about before."

The code *Increased understanding* describes the variety of new topics that students learned in ethics. These included "AI; resources; mining; privacy; monitoring systems; engaging; thought-provoking," as well as "Ethical dilemmas, data privacy, bias awareness, evolving landscape, algorithmic accountability, digital ethics, societal implications."

The code *Different perspectives* represented student learning about multifaceted ethical issues. One student "got to saw [sic] a wide variety of ethic topics; a lot of people took a legal stance which may not be ethical." Another said "I am aware of most ethical issues currently; Most cases discussed are well known; not much felt new or unexpected; I did however see that some people follow unexpected ethical mindsets."

*Engaging learning* showed student experiences with group and peer learning. For example, one student said "Having us choose our own concepts made sure that the ethical concerns were moderately interesting; the in class discussion made sure we actually understood and were

thinking about the ethics instead of just doing a quiz." A third student felt "It was nice to hear about the ethical concerns that other teams found with their projects."

*Mixed responses* described both positive and negative feedback. For example, one student explained "Yes, but much of it felt somewhat basic. A few were quite intriguing though." Others stated that it was "interesting to learn about AI and ethics, but the conversations were shallow and without good structure." For all questions, *Positive* comments were not descriptive of experiences, but generally said that assignments were helpful or enjoyable.

## Support for helping students better analyze ethical implications of projects

Table 3 contains the developed codes and descriptions for Question 2, "Help you better analyze the ethical implications of your own project."

Table 3. Question 2 Codes and Descriptions.

| **Code** | **Description** |
|---|---|
| Context | Background learning on wider ethics topics informing projects |
| Project implications | Critical thinking and deeper analysis of ethical issues related to projects |
| Confidence | Increased confidence in addressing ethical issues |
| Awareness of impact | Increased knowledge of societal ethics issues |
| Increased understanding | Deeper learning of the variety of topics in ethics and their impact |
| Mixed response | Positive and negative feedback of the assignment |
| Positive | General comments on enjoying the assignments |

The code *Context* represented students' background learning on ethics information which brought real-world context to their capstone projects. For example, one student said "There were a lot of ethics presentations about AI which helped contextualize our own project." Another said

“this was great because it allowed us to see how these ethics play out in the real world if they’re related to our project.”

*Project implications* showed how students thought critically about their projects in light of new ethics knowledge. One student said “I had already thought some about the ethical implications of my own project because I wanted to do my capstone project for a company with a good purpose. The ethics session did help me to think about my own project even more and start to analyze every part of it.” A second student said the assignment “Made me think deeper about project consequences,” and another student reported that “Seeing what other people came up with made me think more about the ethical implications of our own project.”

The code *Confidence* described students’ preparedness to explore the ethics of their work, as one student said “I became confident in my ability to analyze the ethical implications of my own project.”

In the code *Awareness of impact,* students described their increased sensitivity to societal issues and how they were connected to their projects. For example, one student said the assignments “Made us open our eyes to potential bias,” while another realized that “Understanding some other ethical concerns made me realize that AI is not something we can just play around with.”

*Increased understanding* again contained a variety of topics that students learned, such as “Ethical guidelines, Critical reflection, Decision-making support, Unintended consequences, Ethical awareness, Moral reasoning, and Accountability assessment,” “goals; risks; fairness; inclusive; accountability; adaptation bias;” and “quality; accountability; consequences; impact; privacy; end-user; evaluation.” One student thought that “Presentations helped widen my knowledge base for future projects.”

*Mixed responses* for this question were ways that students did not feel this assignment was relevant to their project. For example, students believed that “Most of our projects didn't have many ethical concerns, certainly not ours, so it didn't help as much,” that “my project was pretty unique and didn't really follow what was on the modules;” and that “My project has essentially nothing to do with the ethics discussions; It always felt like a bit of a stretch to find ethical issues with our project.”

## Support for students’ choice of ethics topics

Table 4 contains the developed codes and descriptions for student responses to Question 4, “Picking your own ethics topic.”

Table 4. Question 4 Codes and Descriptions.

| Code | Description |
|---|---|
| Agency | Individual choice based on interest, autonomy, and control |
| Researching ethics | Background learning of ethics topics |
| Engaging learning | Enjoyment of active learning assignment |
| Increased understanding | Deeper learning and awareness of ethics through critical thinking |
| Mixed response | Positives and negatives of the assignments |
| Positive | General comments on enjoying assignments |

*Agency* described students' choices of ethics topics based on their interests, which support feelings of autonomy and control. For example, one student said that "It allowed me to deep dive into a subject I was passionate about," a second cited "Flexibility; more creative freedom; teams can explore something related to their project," and a third explained "By picking our own we could choose something that we can relate to and know some stuff about; we could make an interesting discussion about it; Gave wide perspectives on potentially different topics." One student felt that "It was highly valuable getting to pick what topics were most interesting and important to our project. We were able to create powerful content to engage our classmates."

*Researching ethics* referenced the new learning that students experienced while researching their chosen ethics topics for their project. This included a variety of topics on ethics issues such as "Choice;Relevance;Exploration;Personalization;Responsibility;Engagement;Diversity," as well as one student stating "I was able to research and identify diverse array of ethical concerns."

*Engaging learning* described students' positive experiences in group learning and beliefs that the assignments made learning more enjoyable. For example, one student felt that "This made sure we actually cared about the ethics assignment, which made making slides, presentations, and videos about it way easier." Another said "I enjoyed the wide variety of topics we were able to choose from, make it more engaging." Students felt that "Personal interest increased engagement and learning," "Picking our own ethics topic was great because we got to pick something we were actually interested in," and that "By picking our own we could choose something that we can relate to and know some stuff about; we could make an interesting discussion about it; Gave wide perspectives on potentially different topics." Learning in teams was valued by students as "Very flexible in what is considered; having a team was helpful because you got to hear everyone's idea for a news article/ethical issue."

*Increased understanding* showed students' critical thinking and evaluation of ethics implications for their project in light of the research they had done for assignments. One student believed that "It made our whole team think more critically about our ethical responsibility and actually changed how we implemented things," and another said that "I thinking [sic] picking my own forced me to evaluate all possible ethical concerns." One student also thought assignments "Created room for consideration." Students recognized that "the issues found in our specific ethics topic were interesting; the possible issues found in ethical dillemas [sic]; how companies can act unethically; how engineers can act unethically."

*Mixed responses* for this question weighed the benefits and value of assignments, as one student stated "I feel that the ethics presentations were not necessarily the most useful thing in the world, but they were fun and interesting to complete/participate in." Another felt that choice in assignments "led to a few similar presentations because multiple people chose similar/same topic."

## Discussion

After analysis of the quantitative data, as supported by the qualitative data, students confirmed the benefits of learning from the ethics assignments highly on average overall.

For *RQ1: How did the interactive student-led sessions impact students' learning of current ethical issues in computing and relate these issues to their capstone project?*, we found that students were able to relate the ethical issues learned through interactive assignments to their projects in many ways. Students rated the assignments highly overall in informing them of essential ethics topics and in supporting their analysis of ethical issues in their own projects. Students also gave many examples of connections they made, including a wider awareness of ethics at the societal level as well as considering specific implications at the project level. Students were motivated to research ethics topics in greater detail, thereby deepening their understanding of the complexity of ethical issues.

For *RQ2: What was the effect in students' learning in allowing them to select their own ethics topic for the interactive student-led sessions?*, students provided considerable positive feedback on their value of having a choice of topics. Agency was an intrinsic motivator by giving students the freedom to present on topics they were interested in, making the project more enjoyable. The assignments were engaging for students to hear different perspectives from other capstone teams and learn about topics not previously considered. This led to discussions among students and critical thinking of the ethical implications for their projects and in future careers.

Across both RQs, students cited peer learning and agency through choice as engaging factors in ethics assignments. Assignment features that made the work more engaging were hearing about

peers' different perspectives on ethical research, choosing to present on topics that were intrinsically motivating, and participating in group discussions. Students' mixed responses to moderate ratings indicated some areas for improvement on the assignments. However, some mixed ratings of Question 4 may suggest that students did not fully understand the connections between ethics concepts and specific considerations in their capstone projects. This is an opportunity for the researchers to explore new ways to help students identify ethics issues in their projects, especially using peer learning and agency.

## Conclusions and Future Directions

Based on the results, the data indicate that giving students agency to choose the ethical situation to discuss, and allowing them to design an interactive exercise did improve learning ethics topics, especially in understanding ethics implications of their particular project. This is supported by both the quantitative and qualitative data. The novelty of this idea is supported by the rarity of using this pedagogy technique in imparting ethics for a class involving group projects.

This study gives insight on the effectiveness of this pedagogy approach in imparting ethics in a capstone class, in the context of students' group projects. Giving students' agency was effective in enhancing learning, as opposed to other more passive pedagogy approaches of viewing a video or listening to a live lecture. Hearing from other students made ethical implications more real to them, and helped them assess implications that pertained to their project.

This study can be enhanced in the following ways in future studies:

1.) Encourage more instructors in the other capstone classes to try this strategy to determine if the results are instructor(s) specific, or can be generalized. As part of this study, a more comprehensive overview of the pedagogy approach used by capstone instructors should be included, including their rationale. In addition, the study should describe reasons why other instructors feel reluctant to lecture on the topic due to the sensitive nature combined with legislation related to specific topics like DEI.
2.) Encourage instructors in non-capstone class to adopt this strategy for teaching ethics in their classes. Thereafter, collect and analyze similar data to determine if the results are similar for other classes, especially those who have less group work.
3.) Encourage other colleges to adopt this strategy in their classes to determine if the results are specific to CSCE classes.

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