Learning about Ethics in a Multidisciplinary Context

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Introduction

In conjunction with a National Science Foundation-sponsored scholarship program, we have a multidisciplinary peer mentoring support system for STEM students that addresses key professional development areas, including ethics. The students receive financial support and an opportunity to develop academic, professional and life skills through a weekly scholars seminar. The seminar coursework is centered on semester-long investigative projects designed and completed by multidisciplinary teams. A small group of math, science and engineering faculty oversees the seminar and selection of scholars.

Our approach is to provide faculty mentoring while developing stepping-stone peer-mentoring for professional development. This structure supports students and helps them develop leadership qualities. The recipients, as defined by the program criteria, are diverse: multiple majors, male, female, nontraditional students, students with different ethnicities, religious affiliations, backgrounds, and family structure. By including all eligible STEM majors at our university, we have been able to increase the number of women recipients, which creates a sense of critical mass to support the women in engineering.

Our program has demonstrated past successes in addressing issues important to the field and accreditation boards such as functioning on multidisciplinary teams; understanding ethical responsibilities; developing a sense of the global and societal context of STEM work; and supporting the idea of life-long learning.[1,2,3] Our recent focus has been on incorporating ethical studies through the semester-long multidisciplinary projects.

After a brief overview of the multidisciplinary scholarship cohort and associated seminar course, this paper will focus on description and assessment of the team projects from two consecutive semesters that were geared toward improving student understanding of ethical responsibilities. Students were asked to address ethical issues related to their chosen topic. Quantitative and qualitative assessment of student experiences and ethical awareness are presented. Discussion of results includes faculty observations of student learning experiences.

Background

The STEM scholarship is awarded on a competitive basis with an emphasis on selecting students to form a diverse cohort. The intention is to create a group of scholars representing different STEM majors, academic years, gender, race, socioeconomic background, and cultural experience. Scholars are awarded a $5,000 scholarship (providing significant tuition assistance) which is renewable for up to three years. These scholarships are funded by a National Science Foundation S-STEM grant and the selected students must have demonstrated financial need and an eligible declared major (Mathematics, Biology, Chemistry, Physics, Information Technology; Electrical, Computer, Civil, Mechanical and General Engineering; and Automotive, Computer, Electronics, and Manufacturing Engineering Technology). This scholars group is known on campus as the MAX (Mentored Academic Experience) Scholars. In 2013-14, thirty students

were selected from the pool of new and renewal scholarship applications. Because of the range of majors, over half of the students are engineering and engineering technology majors (18 of 30).

The purpose of the MAX Scholars program is to provide STEM students with a mentored academic experience to help them develop and achieve both personal and professional goals. This mentoring takes place in two different ways, taking advantage of the multidisciplinary faculty team and the diverse student cohort. First, each student is assigned primary and secondary MAX faculty mentors, with the primary mentor being a faculty member closely related to that student's field of study. Second, returning scholars serve as role models and mentors for the new scholars. The faculty mentors meet with their mentees at the beginning of each semester and throughout the academic year, as needed.

Scholars are required to participate in a weekly seminar course designed to familiarize students with university resources, provide useful information about a wide array of personal and career issues, and foster relationships with students and faculty across disciplines. Instructional methods for the seminar vary from week to week as well as during each class where the MAX faculty mentors regularly take turns serving as the lead instructor. The seminars include large and small group discussion as well as guest presentations from other university faculty and staff, industry partners, or alumni scholars. This adaptive structure is motivated by best practices, especially for a diverse STEM community with four scholars participating as distance learners.[4-10] Each semester, the seminar course is structured around a multidisciplinary group project addressing a different societal issue pertinent to STEM majors. For two recent semesters, these projects have focused on ethical issues.

Ethics Assignments

The first semester (spring 2013) focused on ethics in a disciplinary context and included an extensive discussion with a philosophy professor about ethical frameworks. The learning approach was through ethical case studies, long used as an approach to teaching ethics (e.g., Harris et al., 2013)[11]. Discipline-based teams discussed and critiqued ethical case studies and wrote reflections. The multidisciplinary context was examined through 1) class-wide discussions and 2) multidisciplinary, small group discussions where students presented their discipline-based case to fellow scholars in other STEM disciplines. The second semester (fall 2013) used multidisciplinary projects to explore the broad topic of "garbage". This is a topic important to society that STEM students, especially engineers, will need to be able to address with ethical responsibility at the forefront of their designs. The learning approach asked students to identify potential ethical problems and solutions to the real world exploration project that they were examining.

During the spring 2013 semester, scholars examined ethical issues by examining case studies from career fields related to their majors. Before reviewing the case studies, the idea of ethics was introduced to the class through a required reading during the Winter Break preceding the semester. Students read "The Immortal Life of Henrietta Lacks", a book documenting the discovery and now widespread use of the "HeLa" cell and the ethical dilemmas involved throughout the process. The story of Henrietta and her family was discussed in class as a way to

provide students with practice identifying and formulating responses to a variety of ethical issues. Once students had a basic understanding of ethical perspectives, a guest lecturer was invited to the seminar to introduce the topic of moral philosophy. The guest lecturer, a philosophy professor, explained several of the more well-known ethical frameworks including Aristotelian ethics, moral relativism, and utilitarianism. This information gave students a framework to consider ethical dilemmas not only in terms of their own responses, but to recognize and understand the variety of potential responses and the thought-process leading to each one. Students were then divided into groups based on major and asked to review and discuss a relevant case study. Case studies were identified from online repositories[12-14] with relevance to our groups of majors as selection criteria. Finally, multidisciplinary groups were formed and each student explained his or her case study to students from other majors, providing an overview of the situation, identifying key players, and addressing each decision that will eventually lead to the problem at hand. These discussions provided a way for students to learn about ethical issues common to other fields as well as hear how students from other majors viewed the case study they had examined.

During the fall 2013 semester, scholars examined ethical issues by focusing on a specific issue within the broader topic of "garbage." Students were assigned to multidisciplinary groups that intentionally included both new and returning scholars from a variety of majors, and when possible, included both male and female students. The ten groups, each consisting of three students, selected topics to investigate such as electronic waste, automobile emissions, garbage islands, pesticide disposal, and composting. Each team researched their topic and gave a presentation to the class covering the background of the problem, possible solutions, and the ethical issues involved. In addition to the presentations, the class watched the film "The Lightbulb Conspiracy"[15], a documentary about planned obsolescence, and a professor in Urban and Regional Studies gave a guest presentation about his work on organic waste recycling in Ghana.

In both semesters, students were given a framework for asking questions about ethical situations (based on Michael Loui's ethics seminars[16]):

1. Identify the affected parties, their interests (rights, expectations, desires), and their responsibilities. Determine what additional information is needed.
2. Consider alternative actions by the main actors, and their possible consequences.
3. Evaluate those actions and consequences according to basic ethical values—honesty, fairness, civility, respect, kindness, etc.—or the following tests:
   Harm test: Do the benefits outweigh the harms, short term and long term?
   Reversibility test: Would this choice still look good if I traded places?
   Common practice test: What if everyone behaved in this way?
   Legality test: Would this choice violate a law or a policy of my employer?
   Colleague test: What would professional colleagues say?
   Wise relative test: What would my wise old aunt or uncle do?
   Mirror test: Would I feel proud of myself when I look into the mirror?
   Publicity test: How would this choice look on the front page of a newspaper?

Assessment Methods

To examine the efficacy of these projects for increasing student ability and the possible differences between them, students were asked to complete a survey about their experience. The survey was administered on paper during regular class time. Because this survey was used to assess classroom experiences, this survey was ruled exempt by our IRB. The survey included 14 Likert-scale items as well as several open-ended questions. Several of the Likert-scale questions were reverse coded to gage if students were reading questions thoughtfully or simply marking one side of the scale. Returning scholars and new scholars each received a different version of the survey because the new scholars had only participated in the fall 2013 ethics project. Items one through ten were identical on both versions, while the last four items were different for new and returning scholars. New scholars were asked to answer two open-ended questions and returning scholars were asked to answer three. The questions on the survey are listed in tables 1-4. The survey was completed by all 30 current scholars, of which 16 are new and 14 are returners. Demographic information collected on the surveys was limited to the students' academic year and major.

The quantitative data from the Likert-scale questions was analyzed simply using mean and variance due to the low sample size. The qualitative data from the open-ended questions was analyzed using the empirical approach.

Table 1 - Likert items for all scholars

Q1	I am more aware of ethical issues in science and engineering because of this project.
Q2	Working on this project had no effect on how I view other societal issues.
Q3	I am more aware of what guides my own ethical decision making after working on this project.
Q4	I am more likely to consider the ethical implications of my decisions in my professional life because of this project.
Q5	I am more likely to consider the ethical implications of my decisions in my personal life because of this project.
Q6	I see no relationship between the class projects and my experience.
Q7	I believe it is important to consider the ethical implications of my decisions.
Q8	I can recognize ethical dilemmas in more situations after working on this project.
Q9	I have an approach for thinking about ethical decision making.
Q10	Ethical issues are discussed in my major classes.

Table 2 - Likert items for new scholars

Q11	I have learned more about ethical issues in my major classes than in the seminar.
Q12	What I have learned in seminar complements my major coursework.
Q13	The returning scholars on my team provided useful input on ethical issues because of their experience.
Q14	Working with a returning scholar did not help the project.

Table 3 - Likert items for returning scholars

Q11	The case study experience from last spring was not helpful as I worked on this project.
Q12	What I have learned in seminar complements my major coursework.
Q13	I have learned more about ethical issues in my major classes than in the MAX seminar.
Q14	My case study experience last semester was more valuable for thinking about ethical issues than the project this semester.

Table 4 - Qualitative questions

New Scholars		Returning Scholars	
Q1	What conversations or materials were most helpful as you looked at ethical issues during this project?	Q1	How did working on the case studies last semester help or hinder this semester's project?
Q2	How did the returning scholar(s) on your team help with the ethical discussion? Would you call them a leader?	Q2	How was the case study helpful for you compared to your teammates who are new scholars?
		Q3	Reflecting on last semester's experience with case studies, and this semester's project, which prepares you better for thinking about real-life situations? Why?

Results & Discussion

Results are presented first for the Likert items and then for the qualitative responses.

Quantitative Responses

Overall, the survey results indicate that scholars are more aware of, and comfortable thinking about, ethical issues in both personal and professional situations after completing the classroom projects. Likert items 1-9 (shown in Table 5), pertaining to awareness and perceived importance of ethical issues received average scores indicating that students either agree or strongly agree with the statements, with the exception of items two and nine, which were reverse coded and received average scores indicating the opposite. This data supports the hypothesis that project participation is an effective way to teach ethical thinking to undergraduate STEM students.

Likert item 10 (Table 5) did not directly relate to the seminar projects, but was intended to determine whether students were exposed to information about ethics in their major classes and whether there was a difference between the diverse majors. Overall, engineering majors had the highest level of agreement with the statement, "Ethical issues are discussed in my major classes." This is likely due to the fact that ethics education is a consideration in the accreditation of engineering programs but not in the other STEM areas represented within the MAX Scholars

cohort. Interestingly, agreement with this statement decreased as grade level increased across all disciplines. This may indicate that students are exposed to ethical issues in introductory courses more so than during their upper-division work.

Likert items 11-14 were slightly different for new and returning scholars (Tables 6 and 7). New scholars were asked to consider statements contrasting their perception of ethical thinking developed through the completion of the MAX seminar projects with the coverage of ethics in their major courses. In addition, students addressed the efficacy of being on a team with a returning scholar who had previous experience discussing ethical issues. Responses indicate that this group of new scholars have not learned more about ethics in their major courses when compared to the seminar, and do consider the scholarship program to be complimentary to their major coursework. Whereas engineering majors responded more strongly to item 10 than other majors because of the impact of program outcomes related to ethics, their averaged response for item 11 was very close to that of the entire group and identical to the group average for item 12. This indicates that the ethics projects in the multidisciplinary context of the seminar have had a positive influence on their overall understanding of ethics issues. In addition, most new scholars agreed that having a returning scholar in their group was useful which highlights the positive impact of peer mentoring on student learning.

Table 5 – Averaged responses to Likert items 1-10

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
New Scholars	4	2.06	3.5	4.06	3.63	1.56	4.5	3.88	3.38	3.5
Returning Scholars	4.07	2.21	3.5	3.79	3.71	2	4.71	3.86	3.57	3
Grade Level										
Sophomore	4	2	3.71	3.86	3.43	1.29	4.43	4	3.43	3.57
Junior	4	2.1	3.3	3.9	3.4	2	4.5	3.6	3.3	3.6
Senior	4.08	2.23	3.54	4	4	1.85	4.77	4	3.62	2.85
Major										
Engineering	3.86	2.29	3.21	3.71	3.29	1.86	4.57	3.64	3.5	3.93
Math/IT	4.14	2.43	3.57	4	4.14	2	4.71	4	3.71	1.71
Science/EngTech	4.22	1.67	3.89	4.22	3.89	1.44	4.56	4.11	3.22	3.44
All Scholars	**4.03**	**2.13**	**3.5**	**3.93**	**3.67**	**1.77**	**4.6**	**3.87**	**3.47**	**3.27**

Table 6 – Averaged responses by new scholars to Likert items 11-14

	Q11	Q12	Q13	Q14
New Scholars	2.25	4	3.75	1.88
Grade Level				
Sophomore	2	4.29	4.14	1.29
Junior	2.6	3.8	3.2	2.4
Senior	2.25	3.75	3.75	2.25
Engineering	2.33	4	3.56	1.78

Table 7 – Averaged responses by returning scholars to Likert items 11-14

	Q11	Q12	Q13	Q14
Returning Scholars	**2.21**	**3.79**	**2.21**	**2.93**
Grade Level				
Junior	2.2	3.6	2.4	2.8
Senior	2.22	3.89	2.11	3
Engineering	3	3.8	3	3

Returning scholars were asked to respond to the same items contrasting the seminar experience with their major courses, as well as two items contrasting the ethics projects they participated in during the spring and fall semesters of 2013. In the spring semester, ethical issues were discussed as case studies; in fall semester, ethical issues were discussed in the context of a multidisciplinary group project. The returning scholars responded to the items relative to their major in much the same way as the new scholars. Similarly to the new engineering students, returning engineering majors were more likely to agree with the statement, "I have learned more about ethical issues in my major classes than in the seminar" than students in non-engineering majors. When asked to contrast the two projects and their different approaches to discussing ethics, it appears that the spring semester case study approach was helpful, but not more valuable than the fall semester multidisciplinary project. When the responses of only engineering majors are considered, three of these four items received an average response of three, or neutral. This is attributable to the small sample size and the responses of one outlier student who responded almost exactly opposite as the rest of the group.

Qualitative Responses

In addition to the Likert scale items, students were asked to respond to several open-ended questions. New scholars were asked what conversations or materials were most helpful to them as they worked on the project, as well as how the returning scholar on their team contributed to the discussions about ethics and whether or not they would consider the returning scholar to be a leader of their team. Responses to the first question were varied, but many students mentioned that it was helpful to hear the opinions of other students, either within their group or through discussions involving the entire class. Several students pointed out their appreciation for the guest presenter (Urban and Regional Studies professor), who talked about his work in Ghana. A common theme throughout many of the responses was that as students became more aware of how ethical issues affect them personally, they found it easier to think about the issues. One student wrote, "*Overall, I think one of the most important aspects of this seminar was the realization that we are going to change the future. Our actions and our decisions are going to shape and mold the world. It is hard to worry about ethics if one feels they have no or limited impact on society.*" Another student noted that "*We were given time, encouragement, and opportunity to focus on what we found to be relevant and pursue topics naturally and progressively*." This is something that is facilitated more easily in a weekly, multidisciplinary seminar structured outside of the traditional engineering curriculum. It also highlights the importance of developing a culture of open dialogue and acceptance of diverse perspectives when discussing ethical issues.

Regarding question 2, which asked how the returning scholar contributed to the ethical discussion and whether they perceived that student as a leader, 14 of the 16 new scholars wrote positive responses and almost all indicated that they view the returning scholar as a leader. One student stated, "*The returning MAX Scholars on my team were great. They were always asking 'what happens if we do that?' They always kept challenging me and the group to think harder. Yes, I would call them a leader because they helped make sure every thing was done and everyone was on task while doing work.*" Because one of the overall goals of the program is to develop leadership skills by modeling positive experiences, this was seen as evidence that the model is functioning and highlights the value of peer mentoring.

Because there were some negative responses, we will develop additional support for teams who have difficult experiences. For example, one returning scholar was unable to participate in the final presentation because of a family medical emergency. Because the student had not sufficiently communicated with his team members (both new scholars), they were unable to do a complete presentation. Setting earlier deadlines for final presentation plans and encouraging the ability for any team member to be able to do the complete presentation will help alleviate negative experiences and help students prepare for similar life emergencies in their future careers. Increased planning and shared responsibility for the group presentation may also avoid a "divide and conquer approach", where the responsibility for specific components of the presentation are distributed to group members, and which often results in disjointed presentations and lack of continuity.

Returning scholars were asked three questions which were meant to contrast the two different projects they had completed and determine if one was more valuable than the other. When asked if working on the first project examining case studies helped or hindered them on the subsequent project, 10 of the 14 returning scholars indicated that it was helpful and the other four responses were neutral. One student described his experience learning from case studies: "*I believe the case studies gave a good background on ethical issues and opened my eyes a lot. It made it a lot easier to see ethical issues in other places.*" One student noted the difference between her experience and the new students on her team "*I was more aware of ethics as an important part of the problem than my teammates. They could see the ethics involved after I suggested the issues.*" This shows the importance of continued discussion about ethics across semesters, as well as the impact of having peer-mentors on student learning.

One student described a strengthened decision-making ability: "*The ethical decision making project from last semester helped to let me know that I have a say when it comes to making ethical decisions. Relating this knowledge to environment and pollution helps me to understand that I can have an impact by the decisions I make on a daily basis.*" Leaving the program with a better understanding of how they can have an impact on the world as engineers and scientists is an implicit goal of incorporating projects with broad societal impact in the seminar. However, the indirect focus of the broader topical assignment did not work as well for every student as highlight by this student's response: "*Last semester's case study prepares me better because it taught me to think in a more ethical way. This semester's project is merely informative, no ownership or ethical thought was dedicated to solving the problems uncovered in our projects. Last semester's case studies gave us an understanding of <u>how</u> to change the world.*" While our

hope had been to specifically seek out ethical thought related to a student-chosen topic, it is clear that this is an aspect of the assignment that will need to be emphasized more in the future.

When asked which project was more effective, responses were split almost evenly between the two semester projects or indicated that they were both equal. One student wrote that he did not value either of the projects, which could be the result of a difficult group experience. One response in particular provided a summation of all of the responses, "*50/50. The case study gave pinpoint perspectives on a specific situation (which could be used to prevent similar sit[uations] in the future) This semester's project gave a larger picture view of consequences of unethical decisions.*"

Faculty Reflection

The MAX Scholars seminar is led by four faculty members and a graduate student, with diverse areas of expertise and backgrounds including engineering, engineering technology, computer science, biology and experiential education. This team selected the ethical framework for the seminar and facilitated discussions with individual students and groups, as needed. Several observations were noted, which are overall consistent with student feedback.

Working with actual topics rather than case studies appeared to be more engaging for students. They seemed to have an easier time making a personal connection with the ethical issues in the "garbage" project topics than with the case studies. During the investigation of the case studies, the students often noted that the ethical choice was obvious. In contrast, faculty observed that the students had a difficult time "pushing the envelope" on the ethical dilemma faced by the individuals described in the case study and that students initial perceptions were challenged when the cases were reframed. However, the students readily connected with the ethical dilemma of electronic waste, composting and other garbage topics as demonstrated by their enthusiasm, ownership of the problem, and creativity as they sought a solution. In the couple of groups where this was not observed, the topic was often chosen by a dominant team member rather than by group consensus, reducing ownership by the entire team. During the team presentations, students asked thought provoking questions and helped each other think more deeply about the ethical issues because of the connections with their everyday life. Several students made comments during their presentations that they now realize that ignorance is in itself an ethical issue and are more committed to learning about the ethical implications of their decisions.

Working on ethical issues in a multidisciplinary group is beneficial for engineering students, as well as the diverse STEM students in our cohort, and provides a challenge that develops insight beyond what students would gain by discussing ethical issues only within their major coursework. Students valued the opportunity to seek solutions to existing ethical issues using the multidisciplinary skill set of the group. By discussing topics, such as composting and recycling of organic waste with a biology major or exploring the cost of electronic waste with a mathematics major, the individual student perspective was expanded to include a range of views on ethical issues that would not be available in their major courses.

We noticed a variety of student abilities when identifying and considering ethical issues. While some student teams could identify issues capably, not all took the next (requested) step of suggesting possible solutions. Some students may have been narrow in their thinking, limited by their preconceptions, or may not have fully appreciated the complexity of the issues. However, when questioned or prompted, students could imagine possible solutions or expand the potential stakeholders in the ethical situation, indicating that their ability to problem solve could be facilitated. Further work examining ethical development in the cohorts is warranted and comprises a necessary part of their STEM training as they increasingly face global, multi-faceted challenges.

As previously noted, some problems arose due to group experiences such as reliance on one student instead of shared responsibility, poor communication, and inability to weave individual student contributions into a cohesive presentation. These laments are very common in academic group course work in general and are not unique to the seminar. However, the involved faculty strongly believe that the benefits of shared work overshadow perceived weaknesses. The group work allowed for a dialogue from diverse students (major, ethnicity, year in academic program, socioeconomic, etc.) that would not be available in individual work. Continuing to support teamwork skill development, especially with scholars returning to the program, should help alleviate some of the difficulties and allow for better development of ethical thinking.

Conclusions

In a multidisciplinary, peer mentoring seminar for STEM students, we explored a variety of ethical issues using both case studies and project-based investigation. Although our sample size of 30 students was relatively small, our results indicate that when teaching ethics, working with actual topics rather than case studies was more engaging for students. Formal work with case studies provided a structured framework that some students appreciated, but faculty observed increased student engagement when topics related more directly to student experiences. The experience of working on multidisciplinary teams in this mentoring cohort continues to expand student experiences beyond their major classrooms, benefitting engineering students as they learn from the perspectives of students in other STEM majors.

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