Student Perception on Ethics and Intercultural Issues in Introduction to Mechanical Design Course

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Abstract

The Citadel Mechanical Engineering Department has been actively involved in adding topics and activities related to ethics and intercultural knowledge to engineering program courses. These undertakings are evaluated using college-wide Value rubrics and Quality Enhancement Plan rubrics, and are also used as graded Embedded Indicators for ABET assessment. Mechanical engineering students involved in these actions are cadets and non-traditional students, including veterans and a constantly increasing number of women and minorities. This paper describes the results of ethics and diversity enhancement efforts in a Mechanical Engineering System Design course that serves as an introduction to a two-semester Senior Design course. Additionally, this paper sums up student perceptions on ethics and intercultural issues as well as their feedback on the enhancement efforts.

Keywords

Senior design, engineering design, ethics, diversity

Introduction

Diversity in the engineering discipline is required to reach its full potential. The engineering profession and engineering education must address the needs of all segments of society in order to better serve all clients and create better products. Increased diversity can be achieved by supporting the education, recruitment, retention, and advancement of diverse groups in engineering education, engineering technology education, and the engineering profession. Studies illustrate these actions can be successful in supporting diversity in engineering given the appropriate resources and collective "will" to propagate effective approaches[1].

Engineering education continuously strives to cultivate inclusive engineering identities and demonstrate how the engineering profession benefits from diversity[2]. Some examples of current engineering practices include advising, mentoring, and collaborating in teams with the purpose of identifying, critically analyzing, and solving engineering problems related to gender, race, and sociocultural differences. Students should be encouraged to think beyond stereotypical perceptions of who belongs to the engineering profession and who it serves toward a more expansive, diverse population. Diverse ways of depicting situations, diverse approaches to a problem, and diverse methodologies in solving problems all strengthen the practice of engineering. Engineering curricula should expose students to engineering practices that value demographic and intellectual diversity.

The new ABET embedded indicators for the 2019-20 academic year include "an ability to apply engineering design to produce solutions that meet specified needs with consideration of public

health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors."

A study of higher education literature on the development of professional identities[3] offers three criteria for developing classroom activities so students can participate in engineering practices, develop engineering identities, and integrate the value of all kinds of diversity in engineering. One criterion states that professors should teach how engineers can collaborate with "non-traditional" engineers (someone other than White men) and non-engineers by exposing students to the unique and important value that diverse individuals bring to identifying and solving problems.

Diversity at The Citadel

The Citadel is committed to educating principled leaders and maintains a responsibility to ensure that every member of the faculty, staff, and student population are treated with the highest levels of honor, duty, and respect. While the focus of The Citadel is to further diversity of student recruiting and enrollment, The Citadel's Mechanical Engineering (ME) Department strives to retain diverse students and be involved in diversity enhancement efforts and activities.

A previous study[4] reported that minority freshmen at The Citadel feel others consider them as a minority. They would be more comfortable both knowing other minority cadets, faculty, and staff and also having a minority upperclassman as a mentor. Juniors are more aware, confident, and secure as minorities and prefer to have faculty or student life residential staff as a mentor rather than a senior.

"Ethics in Action" is the focus of The Citadel's Quality Enhancement Plan, a course of action for institutional improvement that addresses issues contributing to progress in student learning. Faculty, staff, and students have worked together to build components of the curriculum and co-curriculum that were embedded into The Citadel's existing leadership courses, academic majors, and the leadership training program. Enhancing skills related to ethical decision making has been recognized as one of the most pressing needs in society today and has been added to the curriculum. It is The Citadel's requirement to have ethics-related topics and course modules in each academic program. The learning outcomes include (1.) Ethical concept recognition, (2.) Impact of ethics on a profession or discipline and (3.) Application of an ethical reasoning process.

Ethics and Intercultural Issues in Introduction to Mechanical Design Course

Juniors take the MECH 460 Mechanical Engineering System Design course that is a prerequisite for the two-semester capstone Senior Design course. MECH 460 provides experience in the integration of math, science, and engineering principles leading to a comprehensive engineering design project. Open-ended, client-based design problems emphasize a multidisciplinary approach to total system design providing multiple paths to a number of feasible and acceptable solutions, which meet the stated performance requirements. Design teams are required to develop product specifications, generate alternatives through modeling, make practical engineering approximations to include probabilistic approaches, perform appropriate analysis to support the technical feasibility of the design, and make decisions leading to an optimal system

design. System integration, reverse engineering/redesign projects, human factors engineering, products liability, ethics, safety, computer-aided design, maintainability, and fabrication techniques are addressed.

MECH 460 also addresses societal and ethical issues in engineering design. Every year the course is evaluated and two course objectives are assessed based on student performance. Embedded indicators consist of homework assignments and test questions. The two course objectives evaluated are:

- Course Objective 8. Incorporate societal considerations into the engineering design process.
- Course Objective 9. Identify and uphold the ethical standards expected of a mechanical engineer.

Objective student course evaluations demonstrate that awareness of intercultural and ethical issues improves every year. This improvement in awareness could be related to increased incorporation of these topics in various courses throughout the entire college curriculum.

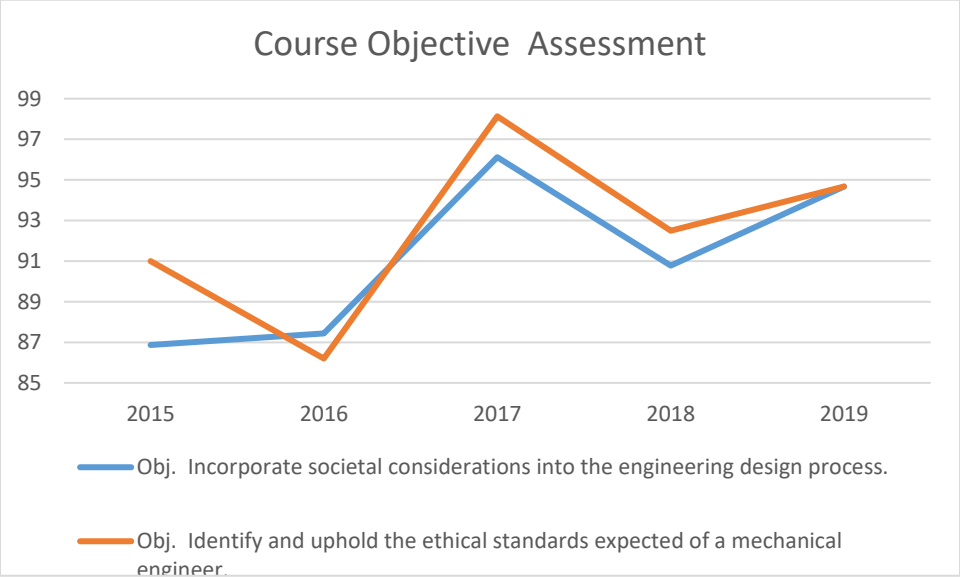

Figure 1. Mechanical Engineering Program Outcomes Assessment for MECH 460

In 2017 The Citadel began using the Quality Enhancement Plan (QEP) "Ethics in Action" rubric shown in Table 1. MECH 460 was designated as a Junior course for student assessment. Every ME Junior writes an essay in response to a posed ethical dilemma related to engineering. Student responses are to suggest, given this ethical dilemma, an appropriate course of action and include National Society of Professional Engineers (NSPE) canons as appropriate. The essay is uploaded to student's institutional E-Leadership portfolio and evaluated as part of the Ethics Across the Curriculum program. It is a mandatory requirement for select courses, MECH 460 in this case, and an overall student requirement for graduation from The Citadel. The essay is then evaluated based on Student Learning Objectives (SLOs) and a grade is recorded in the course and in the student portfolio. Scores for MECH 460 students in 2019 are summarized.

Table 1. QEP Ethics in Action Rubric Used at The Citadel

	value: 1.00	**value: 2.00**	**value: 3.00**	**value: 4.00**	Spring 2019 average score
SLO 1: Ethical Concept Recognition	Student fails to recognize basic and obvious ethical issues and concepts.	Student can recognize basic and obvious ethical issues and concepts and grasp (incompletely) the complexities.	Student can recognize most ethical issues and concepts when issues are presented in a complex, multilayered (gray) context.	Student can recognize ethical issues and concepts when presented in a complex, multilayered (gray) context.	3.92
SLO 3: Impact of Ethics on a Profession or Discipline	Student is unable to describe the impact of ethics on a profession or academic discipline and does not consider the specific implications of the application.	Student describes the impact of ethics on a profession or academic discipline, but does not consider the specific implications of the application.	Student can describe the impact of ethics on a profession or academic discipline, but does not fully consider the implications of the application.	Student can describe the impact of ethics on a profession or academic discipline, and is able to consider full implications of the application.	3.92
SLO 5: Application of an Ethical Reasoning Process	Student fails to apply the ethical reasoning process to an ethical dilemma from their own experience, and is unable to accurately describe why this is an ethical dilemma and fails to evaluate the dilemma using the ethical dilemma paradigms AND decision principles to justify a resolution.	Student inaccurately applies the ethical reasoning process to an ethical dilemma from their own experience, describing why this is an ethical dilemma but fails to utilize ethical dilemma paradigms AND decision principles to justify a resolution.	Student can independently apply the ethical reasoning process to an ethical dilemma from their own experience, describing why this is an ethical dilemma and evaluating the dilemma using EITHER the ethical dilemma paradigms OR decision principles to justify a resolution.	Student can independently apply the ethical reasoning process to an ethical dilemma from their own experience, describing why this is an ethical dilemma and evaluating the dilemma using BOTH the ethical dilemma paradigms AND decision principles to effectively justify a resolution.	2.83

The essays touch a multitude of engineering issues: aesthetics vs. safety, client expectations vs. engineering obligations, benefits to community vs. benefits to company, or engineering obligations vs. employer expectations, just to name a few.

Average scores from the MECH 460 Ethics Assignment for the past three years are shown in Figure 2. No specific trend is evident. The averages are high and range from 3.80 to 3.93, which correspond to 95.0% and 98.3% respectively.

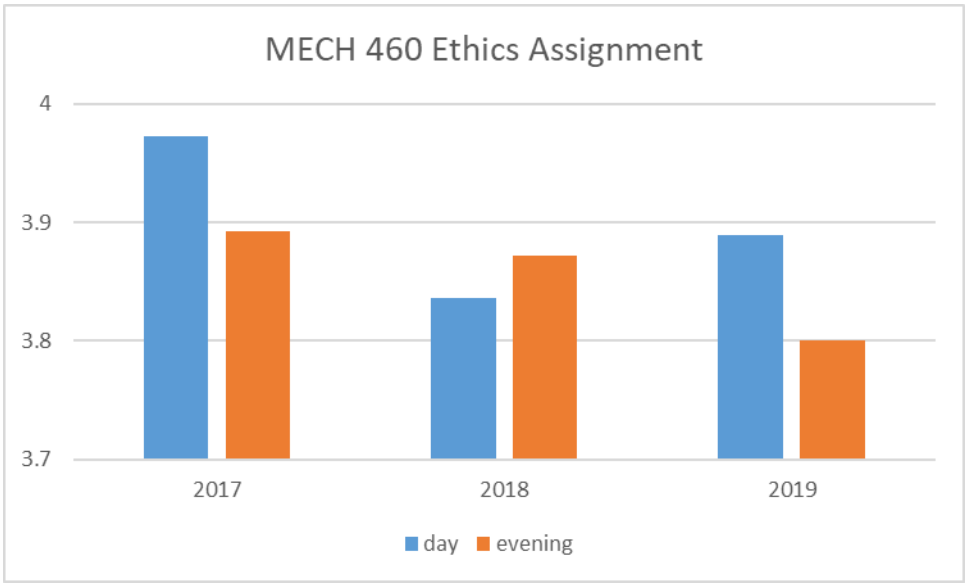

Figure 2. MECH 460 Ethics Assignment Scored Based on Ethics in Action Rubric

In the spring semester of 2019 the authors of this paper instructed students in three day sections and one evening section of the same course. Ethics issues have been added to class topics in previous offerings of this course, mainly as case studies of engineering failures and "what-would-you-do?" discussion; however, this was the first year of incorporating intercultural issues. The Citadel requires assessment of "Personal and Social Responsibility" topics using The Association of American Colleges & Universities (AAC&U) "Value" rubrics[5].

Ethical Reasoning is reasoning about right and wrong human conduct. It requires students to be able to assess their own ethical values and the social context of problems, recognize ethical issues in a variety of settings, think about how different ethical perspectives might be applied to ethical dilemmas, and then consider the ramifications of alternative actions. Students' ethical self-identity evolves as they practice ethical decision-making skills and learn how to describe and analyze positions on ethical issues.[6]

Intercultural Knowledge and Competence is "a set of cognitive, affective, and behavioral skills and characteristics that support effective and appropriate interaction in a variety of cultural contexts."[7]

In order to improve the ethics and intercultural topics assessment, the instructors keep adding class topics, like designing for less developed countries or countries with different main religion, for users with disabilities or for women, and corresponding embedded indicators in homework and tests. Currently every test contains at least one problem that addresses these issues. The assessment includes regular student performance evaluation through grading as well as AAC&U Value rubrics, which are reported to The Citadel's Associate Provost for Diversity, Equity and Inclusion as well as Associate Director for Ethics and Character Development.

Table. 2. Introduction to Engineering Design Junior Year course (MECH460)

1 – totally disagree, 2 – somewhat disagree, 3 – neutral, 4 – somewhat agree, 5 – totally agree

		Day students	Evening students
1.	I understand that the end user influences engineering design.	4.50	4.64
2.	I learned that I have to design differently for diverse users.	4.50	4.57
3.	I learned to consider different genders in engineering design.	3.95	4.36
4.	I learned to design for different cultures.	3.76	4.14
5.	I learned to design for different abilities.	4.34	4.43
6.	I learned to design for different environments.	4.52	4.57
7.	I learned to identify potential ethical dilemmas in engineering practice.	4.22	4.50
8.	Incorporating gender issues in engineering design courses is necessary.	3.71	4.00
9.	Incorporating cultural issues in engineering design courses is necessary.	3.86	4.21
10.	Incorporating environmental issues in engineering design courses is necessary.	4.29	4.64
11.	I am comfortable working with engineering clients and colleagues from diverse racial/ethnic backgrounds.	4.57	4.93
12.	I am comfortable working with engineering clients and colleagues of the opposite gender.	4.53	4.86

Table 2 presents the survey data from 58 of the 69 day students and 14 of the 17 evening students who participated in the MECH 460 course in the Spring 2019 semester. Based on student ratings of 4 to 5 (somewhat to totally agree), the course assignments and content seemingly provides an opportunity for understanding that the end user influences design, for learning to design for diverse end users of different abilities and in different environments, and for identifying potential ethical dilemmas in engineering. Moreover, these students feel comfortable with ethnic and gender diversity in colleagues and clients. The students were neutral to somewhat in agreement with the necessity of, and that they learned about, incorporating gender and cultural issues in design. Evening students' responses had scores higher by 0.26 on average with significant difference of 0.35 points or 9 relative percent for questions 3, 4, 9, 10 and 11. It is worth to note that evening section has a bigger percentage of women. Day sections have only 1 female student (1.4%) while the evening section has 4 women (23.5%).

Additionally, the evening students include non-traditional students whose larger life experiences may improve their perspective on diversity.

This was the first course where assignments specifically focused on designing for ethnic and gender diversity. As a majority of students in this class are White, American males, the survey results are not unexpected.

Conclusions

These initial results suggest that students have an understanding of the need of designing for diverse users. The instructors of the MECH 460 course will continue to incorporate assignments targeting diverse gender and ethnic needs in engineering design. In future offerings, the authors will also create projects that allow evaluating the students in designing for diverse users.

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