Enhancing Engineering Ethics Curriculum by Analyzing Students' Perception

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1. Introduction

The College of Engineering at North Carolina A&T St University (NC A&T) is committed to educating their students on their ethical responsibility to prepare them for their profession. Unethical choices have damaged the reputation of professionals and organizations and accrediting bodies, such as the Accreditation Board of Engineering and Technology (ABET, Inc.), have been dedicated to include ethical knowledge of students as a part of the accreditation process for institutions. ABET, Inc. requires as per criterion 3f, "an engineering graduate should demonstrate an understanding of professional and ethical responsibility". Although these requirements are mandatory, there are no set guidelines of how to achieve the goal to demonstrate ethical knowledge. North Carolina A&T State University program outcomes are achieved by exposing students to a variety of subject material across the undergraduate curriculum and effectively teaching students across these courses how to preserve and enhance the engineering profession including ethical and legal practices. The Department of Industrial and Systems Engineering of NC A&T engineering courses that specifically address ethics in their objectives is GEEN 100- Engineering Design and Ethics, INE 289- Engineering Teams and Leadership, INE 389- Systems Approaches for Industrial and Systems Engineers, and INE 489- Professionalism and Ethics for Industrial and Systems Engineers. In order to effectively enhance the engineering ethics curriculum and to assess and document the current ethic instruction coverage, an interdisciplinary faculty group received a grant from the National Science Foundation (NSF) to help achieve this objective. This paper will discuss two main objectives: 1. Understand and evaluate the results of a college-wide survey administered to gauge the perceptions of undergraduate and graduate engineering students regarding their current ethics instruction. 2. Identify areas in the ethics curriculum that might need to be strengthened, and suggest a more informative way of enhancing ethics instruction at NC A&T.

2. The Need for Ethics Instruction in Engineering

Over the years, Universities have shown concern about raising the ethical knowledge of students by finding ways to influencing their ethical reasoning. In addition, in light of the many high profile news stories about unethical business practice, many industry and academic leaders have stressed the importance of increasing ethics content in engineering courses [1]. Engineering students handle a lot of courses in their curriculum. Many programs are full of technical information and leave little room for students to develop professional practices that aid them to become skillful communicators, ethical decision makers, team leaders, creative thinkers, and problem solvers. Professional practices are essential and critical, since engineers regularly interact with all types of people in the world and create technical solutions that address complex social and environmental issues. Moral education could not be divorced from the school curriculum. Rather, it should be delivered through all of the agencies, instrumentalities, and materials of school life [2]. Some courses in the curriculum have introduced engineering students at North Carolina A&T State University to professional ethics by using in-class discussion of ethics case studies, ethics videos, reading and writing assignments, and online instructional

materials. It has been suggested to consider professional codes of ethics in engineering as a useful framework for thinking about the student learning outcomes in the area of ethics and professional responsibility [3]. Faculty of different universities have approached teaching ethics in a variety of ways in order to find the most effective ways to improve ethics awareness and ethical decision making in students training for jobs to produce the best ethical practitioners, and there is a continuous debate across disciplines to find the best approach or method. Professors suggested that the morals, values and ethics we want students to learn should be identified by adults and taught by matching the topic and level of intensity to the student's developmental level [2]. As a result, there has been a great deal of recent literature describing how programs are integrating ethics into their curriculum with the majority of this literature focusing on content such as ethics cases or new course development; very little research has been done on assessing and comparing the impact of various delivery methods [1].

During fall 2008, an interdisciplinary faculty group at Virginia Polytechnic Institute and State University (VPI)Virginia Tech received a 3-year grant titled "graduate interdisciplinary liberal engineering ethics (GILEE)" from NSF under the Ethics Education in Science and Engineering (EESE) program. The GILEE curriculum is continuing to be developed by investigators at Virginia Tech: however the provisional curriculum was examined at North Carolina A&T State University (NC A&T) and the University of Illinois-Chicago. NC A&T faculty members have been discussing ways to assess the current status of ethics instruction, particularly in engineering, and enhance undergraduate and graduate curricula by introducing ethics instruction at various levels.

3. Conducting Perception Survey in the College of Engineering (CoE)

To measure students' knowledge and attitudes pertaining to their current ethics instruction and to gain a true understanding of how effective these approaches may be in the classroom at NC A&T, some type of assessment had to be created. As part of this project, a survey was developed by investigators, to measure the perceptions of undergraduate and graduate students, in the college of engineering.

The results from the survey will be used for the following purposes: 1. to provide a baseline measure of how students perceive their current ethics instruction and how they understand ethical issues, particularly as they relate to global differences, issues of advocacy and ethical leadership, and ethics and emerging technologies. 2. To identify areas to improve student perceptions regarding their ethics training and provide some directions for curricular planning for the college of engineering at NC A&T. VPI investigators consisted of an interdisciplinary group of engineering faculty, assessment professionals, and survey practitioners, to generate item pools for each of the two sections.

The survey consisted of two sections. The first was focused on "perceptions of the curriculum" and included 11 items. For each item, students were asked their level of agreement or disagreement according to a five-point scale: 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), 5 (strongly disagree). Table 1 includes the 11 items for the "perceptions of the curriculum" section.

Table 1: Perceptions of the Curriculum

Perceptions of the Curriculum Scale Items
1. In my curriculum, there has been a substantial emphasis on teaching ethics.
2. I have been taught about an engineer's (business person's) core values and their relationship with effective ethical leadership.
3. The textbooks and course materials I have used in this program often cover ethical issues.
4. My curriculum has informed me of the many ways in which professionals can become effective advocates for ethically relevant decisions and legislation.
5. As a whole, my professors have avoided discussions of difficult ethical issues.
6. In my classes, cultural differences in ethics has been discussed.
7. In my classes, I have often had the opportunity to initiate discussions regarding ethical issues.
8. Many examples of the relationship between emerging technologies and ethics have been discussed in the classes that I have taken.
9. I have been taught the differences between ethical relativism and ethical absolutism.
10. As a whole, my professors demonstrate a great deal of knowledge regarding ethical issues.
11. My professors have often expressed concern over ethical issues in applied settings.

The second section of the survey focused on "perceptions of ethical issues" and included 11 statements to which students could agree/disagree on the same five-point scale: 1 (strongly disagree), 2 (disagree), 3 (neutral) , 4 (agree), 5 (strongly disagree). Table 2 includes the 11 items for the "perceptions of ethical issues" section.

Table 2: Perception of Ethical Issues

Perception of Ethical Issues Scale Items
12. Ethics in engineering (business) is accepted as the same across cultures and nations.
13. Ethical concerns do not apply to most of us in engineering (business) because engineering (business) is separate from society.
14. If an engineering (business) practice is legal, then it is also necessarily ethical.
15. In general, ethics is independent of the country or culture in which it occurs.
16. Active advocacy on the part of an engineer (business person) has no potential to influence legislation.
17. Ethical leadership is not a concern in engineering (business).
18. Ethics is too complicated and cannot be taught.
19. Professional ethics and personal ethics are two separate things.
20. Ethics do not vary from situation to situation.
21. Ethical issues do not pertain to technological advances.
22. In general, the accepted practices of cultures in other countries determine what is ethical.

3.1 Data Analysis

After approval from the university's Institutional Review Board, different undergraduate and graduate classes in the College of Engineering were randomly selected to answer the questions of the survey. The facilitator was instructed to give a brief overview of the purpose of the survey, asking for students' responses and assistance. No identifying information related to individuals was collected, though demographic items on the survey included age, gender, level of study (freshman, sophomore, junior, senior, master's, doctoral), primary area of engineering (Industrial and System, Civil, Mechanical, and etc.).

The analysis gauged the perceptions of undergraduate and graduate students, both in engineering and business programs, regarding their current ethics instruction. The responses were analyzed to identify if any correlation existed between students' perception of curriculum and perception of ethical issues. Differences in item means were compared through t-test, with a $p<.05$ indicating significance for each item among the following groups:

- ✓ NC A&T undergraduate engineering and business students.
- ✓ ISE undergrad students and undergrad students across disciplines in the Engineering Department
- ✓ NC A&T and VPI undergraduate engineering students.

4. Results from Survey

Survey responses were received from 354 NC A&T engineering, 88 business and 563 VPI engineering undergraduate and graduate students. The represented engineering majors included architectural, civil, mechanical, industrial and systems, bioengineering, biological, chemical, computer engineering, computer science, aerospace, construction engineering and electrical. Table 3 shows a complete demographic breakdown for each group.

Table 3: Survey Response Characteristics

	All NC A&T Engineering		NC A&T Industrial and System Engineering		VPI Engineering		NC A&T Business	
	(%)	(n)	%	(n)	(%)	(n)	(%)	(n)
Age :								
18-24	80%	283	75%	74	85 %	479	88%	77
25 +	20%	71	25%	25	15%	84	12%	11
Gender:								
Male	68%	241	59%	58	74%	417	46%	40
Female	32%	113	41%	40	26%	146	54%	48
Year of Study:								
Freshman	32%	113	8%	8	21%	117	8%	7
Sophomore	14%	50	1%	1	17%	97	16%	14
Junior	21%	74	24%	23	15%	84	23%	20
Senior	22%	78	38%	37	25%	138	53%	47
Master's	5%	18	12%	12	10%	58	-	-
Doctorial	6%	21	17%	17	12%	67	-	-

4.1 All NC A&T Engineering Students vs. Business Undergraduate Students

The Perception of the Curriculum

Out of 11 questions from table 1, seven had a significant mean difference and Business students were more likely to believe the following: Question #1) Their curriculum has a substantial emphasis on teaching ethics. Question #3) Their textbooks and course materials often covered ethical issues. Question # 2) They have been taught about a professional's core values, effective ethical leadership and how to become effective advocates for ethically relevant decisions and legislation. Question # 10) Their professors demonstrate a great deal of knowledge regarding ethical issues. Question #11) Their professors expressed concern over ethical issues in applied settings. All students agreed less than 30% that they were exposed to ethical terms and less than 25% agreed that their professors were avoiding discussions of difficult ethical issues. All

engineering students were less likely to believe that cultural differences in ethics have been discussed in their classes.

Perception of Ethical Issues
Out of 11 Questions from table 2, three items showed a significant mean difference to the following questions: Question #18) Ethics is too complicated and cannot be taught. Question #21) Ethical issues do not pertain to technological advances. Question #13) Ethical concerns do not apply to my profession because my profession is separate from society. Business students believed at higher agreements to the following questions: Question # 12) Ethics in engineering (business) is accepted as the same across cultures and nations, question #20) Ethics do not vary from situation to situation, and question #19) Professional ethics and personal ethics are two separate things.

Overall the results indicate Business students perceived greater engagement with ethics education than Engineering students. These results could be evident because courses taken in business school may put more of an emphasis on ethical discussions. The majority of the Engineering students seem to have more awareness of ethical issues even though they believe to have less exposure in the classroom. "Nationally, schools of business have hired faculty to teach ethics courses and have spent considerable time infusing ethics instruction throughout their curricula" [4].

4.2 All NC A&T Engineering Students vs ISE Undergraduate Students

Perception of the Curriculum
Out of 11 questions from table 1, four had a significant mean difference with the following items: Question #2) I have been taught about an engineer's core values and their relationship with effective ethical leadership. Question #3) The textbooks and course materials I have used in this program often covers ethical issues. Question #4) My curriculum has informed me of the many ways in which professionals can become effective advocates for ethically relevant decisions and legislation. Question #5) In my classes cultural differences in ethics have been discussed.

Engineering undergraduate students perceived to be less exposed to ethics in the following: the curriculum's material. There has been a substantial emphasis on teaching ethics. The textbooks and course often cover ethical issues. Also a Professional core values, ethical leadership, ethical terms, and Cultural Differences.

Over 70% of the ISE undergraduate students believed the following: Question #10) their professors demonstrated a great deal of knowledge regarding ethical issues. Also for Question #4) these same students have been informed of many ways in which professionals can become effective advocates for ethically relevant decisions and legislations.

Perception of Ethical Issues
When comparing the two samples, there was not a significant mean difference with all of the questions, but agreed at the same low rates for the following questions from table 2: Question #13) ethical concerns do not apply to my profession because my profession is separate from society and Question #19) professional ethics and personal ethics are two separate things.

ISE undergraduate students believed to have had more exposure to ethics studies, but agreed at higher percentages with the following questions from table 2: Question #21) Ethical issues do not pertain to technological advances. Question #12) Ethics in my profession is accepted as the same across cultures and nations. Question #15) Ethics is independent of the country or culture in which it occurs. Ethics do not vary from situation to situation. Less than 15% of ISE undergraduate students believed the following items from table 2: Question #17) ethical leadership is not a concern in their profession, question #18) Ethics is too complicated and cannot be taught, and question #13) ethical concerns do not apply to most of us in my profession because my profession is separate from society.

Overall, the results indicate ISE undergraduate students perceived that their ethics training and exposure were more positive than the engineering undergraduate students. This could be evident because ISE students may take more management related courses that could have more ethical discussions. Although ISE undergraduate students believe to have more exposure, they also believe that more class discussion of culture difference, ethical terminology, and professional/personal ethics is needed.

4.3 NC A&T and VPI undergraduate Engineering Students

Perception of the Curriculum

Out of 11 questions from table 1, nine had a significant difference. Some of the differences were identified with the following items: Question #6) Cultural differences pertaining to ethics have been discussed. Questions #11) Professors have often expressed concern over ethical issues in applied settings. Question #7) I have often had the opportunity to initiate discussions regarding ethical issues. Questions #8) Many examples of the relationship between emerging technologies and ethics have been discussed in the classes that I have taken.

NC A&T and VPI engineering students perceived to be exposed to ethics at similar agreements and didn't have a significant mean difference in the following areas: Question #1) In my curriculum, there has been a substantial emphasis on teaching ethics. Question #2) I have been taught about an engineer's core values and their relationship with effective ethical leadership. NC A&T engineering students were more likely to believe in their curriculum: Question #8) There has been discussions about the relationship between emerging technologies and ethics and VPI Engineering students believed at higher rates question #5) that their professors were avoiding discussion of difficult ethical issues.

Perception of Ethical Issues

NC A&T and VPI engineering students had similar agreements for a majority of the questions pertaining to ethical issues, but nine out 11 questions showed a significant mean difference.NC A&T Engineering students are more likely to believe the following: Question #12) Ethics in their profession is accepted the same across cultures and nations. Question #14) If a professional practice is legal, then it is also necessarily ethical. Question #17) Ethical leadership is not a concern in our field. Question #21) Ethical issues do not pertain to technological advances.

Both groups believed at similar agreements to the following questions: Ethics is too complicated and cannot be taught and Ethics do not pertain to technological advances.

5. Focus Groups

As part of the study design, focus groups were conducted to examine more fully student responses to the survey in an attempt to further validate the instrument and to have an open discussion about the items relating to the survey. There were four different focus groups that had three or four junior/senior students that were conducted in an undergraduate industrial and system engineering class. The groups consisted of the following: 1. International students, 2. All males, 3. All females, 4. Small town residents. Students were provided with six questions from the survey and were asked about their own experiences and opinions of current ethical training in their curriculum. They were also asked for suggestions for improvement. All the groups seem to follow the same trend of opinions during group discussions. The following results were discovered from having the focus groups. Majority of the students felt, learning about ethics and ethical behavior is an important part of the curriculum, but ethical instruction could be improved. Many classes that discussed ethics were at freshman level or electives. During their freshman year these courses cover the basic of ethics, but never challenged them to think deeply about possible unethical situations which they could be involved in their profession. Majority of the students felt Ethics can be taught, but instructors must find creative ways to expand a student's way of thinking and help improve moral reasoning skills. Students suggested that their ethics curriculum could be enhanced by holding Ethics Workshops or seminars where engineers from the industry could come in and discuss their ethical experiences and real life ethical dilemmas that can potentially occur in the workforce. Also, these students commented having role playing exercises from ethical scenarios and present to workshop attendees. Students also suggested having additional ethics courses in the curriculum that relate to "Cultural Ethics" because culture ethics was rarely discussed or discussed at all. Additionally, implementing ethics component in all courses to show relationship of how ethics related to that course topic. Finally, the students showed a need for more case studies and discussion in upper class courses to provide soon-to-be graduates with more hands on ethic training to increase their knowledge on how to apply ethics in real life situations.

6. Current Industrial and System Engineering Curriculum (ISE)

6.1 ISE Program Outcomes

The specific program outcomes, measured in terms of the knowledge and skills the graduates of the BSISE program are expected to possess upon graduation, are given below in table 4. Program outcomes are achieved by exposing students to a variety of subject material across the undergraduate curriculum. Table 5 shows where each outcome is to be assessed for undergraduate program improvement purposes.

Table 4: Specific Program Outcomes

a	Apply knowledge of mathematics, science, and engineering
b	Design experiments, collect, analyze and interpret data from a variety of sources
c	Design or improve integrated systems or processes consisting of people, materials, information, equipment and energy considering life cycle factors
d	Ability to work in multidisciplinary teams
e	Formulate and solve engineering problems
f	Preserve and enhance the engineering profession, including ethical and legal practices
g	Communicate effectively
h	Recognize global environmental, economic and societal issues
i	Describe role of lifelong learning in career plan
j	Gain industrial experience
k	Utilize tools of information technology and project management skills

Table 5: ISE (ABET, Inc.) Program Outcomes

ISE (ABET) Program Outcomes	**a**	**b**	**c**	**d**	**E**	**f**	**g**	**h**	**i**	**j**	**k**
Freshman-Level Classes											GEEN 162
Sophomore-Level Classes	INEN 246		INEN 255	INEN 289	INEN 255	INEN 289	INEN 289		NEN 380	NEN 246	NEN 380
Junior-Level Classes	INEN 435	INEN 370	INEN 465		INEN 430	INEN 389	INEN 389	INEN 361		NEN 471	NEN 435
Senior-Level Classes	INEN 425	INEN 475	INEN 446	INEN 595	INEN 415	INEN 489	INEN 489	INEN 495	NEN 495	NEN 495	NEN 495

Currently, NC A&T ISE engineering courses that specifically address ethics in their objectives are the following:

- ✓ One core course *(GEEN 100) Engineering Design and Ethics-* This course introduces students to engineering and computer science disciplines and functions, professional licensure, the Fundamentals of Engineering exam, code of ethics, safety, the design process, creative thinking, teamwork, and technical writing. A case study on ethics and the application of the design process through a team project are required.

- ✓ Elective Course (*INE 289) Engineering Teams and Leadership*-This course covers industrial relations and organizational structures, project management, teamwork, interpersonal skills, and leadership in an engineering organization.

- ✓ Elective Course *(INE 389) Systems Approaches for Industrial and Systems Engineers*- This course introduces current techniques for systems design, analysis and improvement.

- ✓ Elective Course *(INE 489) Professionalism and Ethics for Industrial and Systems Engineers*- This course covers professional licensing, professional practice, ethics, laws and regulations such as the Americans with Disabilities Act, and the role of continuing education.

7. Enhancing the Current Ethics Curriculum

In order for students to internalize an ethical mindset, they need the opportunity to discuss and find adequate solutions to ethical issues throughout their undergraduate courses [5]. The results from the survey and focus group were discussed during an ISE faculty meeting in order to improve the ISE curriculum. A list of topics was generated during a brainstorming session about what ethics topics are applicable for an ISE student to learn the foundation of engineering ethics in their curriculum. The following list was generated, but is being currently expanded due to current research:

• Ethical Theories	• Ethical Principle
• Framework for Moral Reasoning	• Ethics in Research
• Ethical Analysis	• Ethics in Design
• Safety, Risk, and Liability	• Professionalism
• Codes of Ethics	• Legal Obligation
• Environmental Ethics	• Social Impact of Technology
• Engineering and Sustainable Development	• Communication/Coordination
• Dealing with Customer Specification Problems	• Whistle Blowing

A Standard rubric used to assess each the f outcome, Preserve and enhance the engineering profession, including ethical and legal practices, are provided on in Table 6.

Table 6: Standard Rubric to Asses Criterion f Outcome

Indicator	Unsatisfactory (1)	Developing (2)	Satisfactory (3)	Exceptional (4)
Ethical Self-Awareness	Students not able to articulate core beliefs and values.	Student able to articulate core beliefs and values and their origins.	Student able to articulate core beliefs and values and perform self analysis.	Student able to articulate core beliefs and values and perform self analysis with exceptional depth and clarity.
Identification of Ethical/Legal Issues	Student fails to identify ethical/legal issues.	Student partially identifies ethical/legal issues.	Student identifies all intended ethical/legal issues.	Student identifies all intended ethical/legal issues, and discusses the relevance of these issues to the case.
Stakeholder Positions	Student does not identify/consider stakeholder(s) positions related to the ethical/legal issues(s).	Student correctly identifies/considers a single potential stakeholder's position related to the ethical/legal issue(s).	Student correctly identifies/considers more than one potential stakeholders' positions related to the ethical/legal issue(s).	Student correctly identifies/considers a wide range of potential stakeholders' position related to the ethical/legal issue(s).
Resolution	Student fails to provide a potential resolution to the problem.	Student provides problem resolution, but does not consider alternatives.	Student considers alternative ways to resolve the issues with some discussion of merit of each alternative.	Student considers more than two alternatives ways to resolve the issue(s) , and discusses their potential effects on all stakeholders.

The current ethics courses, GEEN100, INEN289, INEN389, and INEN489, touch on the basics of some of the topics listed above, but these courses don't go into deep discussion or show relationship to technical courses taken in the curriculum. Given the fact that one class is required as a freshman and the other three are electives, students are not provided with the exposure to complex ethical issues to develop into professional practices that become skillful ethical decision makers. Some recommendations were implemented during the fall semester of 2012 to enhance the ethical coverage in an ISE core course. These topics were covered in a series of graduate ethics research presentation and in a quality assurance class to be an example of how instructors can insert ethics modules into a technical engineering class.

7.1 Ethics Research Presentations

A series of engineering ethics seminars was created as a component of an Industrial & System Engineering (ISE) Graduate Student Seminar class during each spring semester for the past 3 years in order to increase awareness of the importance of Engineering Ethics. The ISE graduate

program coordinator invited several speakers to the university to present their research on ethics to graduate students. The seven common topics presented by graduate students were as follows:

- ✓ Institute Review Board
- ✓ Research Misconduct
- ✓ Intellectual Properties
- ✓ Conflicts of Interest
- ✓ Definition of a Human Subject
- ✓ Authorship and Peer Review
- ✓ Industrial Engineering Professional Code of Ethics

The presentations were well received by the participants and faculty saw the presentations as a great way to start a broader conversation about ethics on campus and expressed interest in identifying other opportunities for engineering ethics discussion for curriculum enhancement.

7.2 Integrating Ethics into an Undergraduate Quality Assurance Course

An approach to inserting an ethics component into a senior level statistical quality control course was implemented to increase ethics coverage in the curriculum and to involve students in ethical problem solving within the classroom. This class had 34 students enrolled and was 3 credit hour course. Since the technical content is rather complex, only limited time was available to focus on ethical issues. However, even limited discussions provide an opportunity to reinforce the importance of ethics in a professional career and how it related to the course. The following topics were covered, but not limited to in the class discussion and group presentations:

- ✓ Ethical Decision Making
- ✓ Engineering Code of Ethics
- ✓ Safety to humans and animals
- ✓ Dealing with customer specification problems
- ✓ Whistle Blowing
- ✓ Environmental factors
- ✓ Risk, Safety, and Accidents

Two class sessions were devoted to ethical decision-making, with application to several quality related ethic case scenarios. In addition, groups that consisted of four members were formed to complete a take home ethics assignment to answer and discuss ethical scenarios that related to the industrial engineering field. A small research project was assigned that required students to research engineering ethics with emphasis on manufacturing or service related quality issues. Also, students were required to create a five to ten minutes class presentation discussing their research that included an article review that addressed practical applications and real life ethical issues.

7.2.1 Student Feedback and Comments from Course

To assess the effectiveness of the ethics exercises, the professor asked random students, from the statistical quality control course, their opinions of how well the ethics related topics/work was incorporated in the class. A majority of students felt that this course increased their awareness of

ethics issues and increased their ability to deal with ethical issues. Most of the students that did not see a change in their perceived importance of ethics commented that they already recognized its importance, but overall the students felt that the amount of time spent on ethics in this course was about right, but commented they wish a little more time could have been spent discussing a few more case studies and evaluating potential decisions.

Some of the student's responses that were recorded regarding additional ethical coverage in the quality course: One junior student commented that, *"The presentations gave specific examples of ethically challenging situations that have occurred in the real world and provided us with the opportunity to analyze and think of possible actions."* One international student commented that, *"The group quiz changed my understanding by showing that not all ethics decisions are cut and dry."* A senior level student commented, *"Having the class discussions and group scenario assignment helped develop my thought process to come up with options when dealing with ethical issues."*

Raising questions on engineering ethics issues throughout the ISE courses helps faculty members review their teaching content, which will result in better curriculum enhancement and the coming accreditation visit in the near future. As the ISE faculty are discussing the survey results, the focus group results, and the quality assurance course feedback to improve the ISE undergraduate curriculum, many more students will conspicuously gain benefits in the coming years.

8. Summary

This paper summarizes the collaborative efforts of an interdisciplinary group of faculty working to enhance ethics instruction in graduate and undergraduate curricula at Virginia Tech and North Carolina A&T State University. North Carolina A&T State University has implemented this project by conducting major activities by conducting an ethics instruction survey in the College of Engineering at NC A&T created by VPI Investigators, holding focus groups with students, inviting guest speakers to present their research on ethics to industrial and system engineering graduate students and showing how ethics modules can be implemented into a technical engineering course. It has been clear that to provide education on engineering ethics is very much needed and even essential, especially at NC A&T as there are many first generation college students. The items on the survey conducted provided a scaled measure of students' perceptions of ethics teaching in their curriculums. However, students' knowledge regarding aspects of ethics is more difficult to determine, in part because engineering students may lack the specific language skills and perspectives to discuss characteristics of ethics and the consequences involved from choices that are made in ethical dilemmas. Most of them were aware of these critical ethical issues, but felt they have not had many opportunities to discuss them. In addition, the graduate student seminar series really opened the eyes of many graduate students and a new curriculum revision in the ISE department will certainly help many undergraduate students increase awareness of the importance of engineering ethics. The focus groups identified ways to help improve the ethical training for students from the student's perspective and to obtain a deeper understanding of what ethical discussion is taking place in the classroom. The ethics module in the Quality Assurance class was a good example of how ethics can be incorporated into a core course where students can understand the connection of ethics to those specific class objectives. The Survey, Focus Group, and the Quality Assurance course also identified the need for more faculty training regarding ethics education, so there can be more meaningful discussion

in the classroom and also learn additional teaching methods. Discussions on engineering ethics with undergraduate students help them understand what kind of professional attitude they need, which in turn prepares them for developing better graduate research work and for becoming a member of a future workforce. In addition, other engineering departments at NC A&T are expected to use the survey results to improve their teaching contents.

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