Using Case Studies to Improve ECE Undergraduate Performance at Identifying Ethical Concerns

Miriam E. Sweeney, Claire Major, Todd J. Freeborn

Background and Need

Effectively teaching ethics in in engineering remains a challenge for educators. Our team examined differences in ethical reasoning in first-year electrical and computer engineering undergraduates after participating in an introductory course redesigned to emphasize ethical reasoning alongside foundational EE concepts and delivered in both lecture-based and problem-based learning (PBL) formats.

The initial study comparing the efficacy of lecture to PBL in supporting ethical reasoning found no difference between the two teaching styles. However. while evaluating student work in Year 1, the study team noted a large proportion of students had challenges correctly identifying the ethical dilemma(s) (and most appropriate IEEE codes of conduct) for the scenario given.

Approach

To help students practice identifying ethical dilemma's, a total of six ethical case studies (developed and published by R.C. Woods, D.A. Conner, G.-A. Capolino, and G. Adamson, and the IEEE/EMCC Member Support Subcommittee) were included in six ECE 121 course assignments in the Fall 2022 and Spring 2023 iterations of ECE 121.

These case studies are fictitious examples to illustrate ethical issues that can arise in the engineering profession. Each case outlines the context, event, potential complicating factors, and authors commentary on the appropriate IEEE code of ethic relevant for the case (see example).

For each case study, students were asked to identify the most relevant IEEE code of ethic for this situation (or report if none applied) as a multiple-choice question. After the submission deadline, the commentary provided by the case study authors detailing the ethical problem and code of ethic most relevant for each case study was made available to students. This was provided to help them increase their understanding of the most relevant code of ethic for each case.

Example Case Study

Table 1. Case studies added to ECE 121 assignments for student practice to identify most appropriate Code of Ethic relevant to different situations.

ID	Case	Code
1	**[Context:]** Part of Christopher's job is final inspection, immediately prior to shipping, of all the Tergic Blips made by Exalted Electrical Engineering Pvt. Ltd. Christopher has been given wide latitude regarding what should be inspected as this is a "back stop", to catch any obvious manufacturing defects that should have been caught earlier in the inspection process, to make absolutely sure that customers find no cause for complaint with Exalted Electrical Engineering's products. **[Event:]** One day Christopher finds that the electrical insulation on all the Tergic Blips he tests that day is faulty and might be dangerous under some conditions. He makes some enquiries of the production staff and finds that Shoddy Materials Inc. was contracted to supply the insulation the previous month, and that all their parts have performed badly under this test. As a result, all the Tergic Blips previously sent out with insulation from Shoddy Materials may be potentially faulty. He reports the facts to his supervisor Dusty, the Senior Production Manager of Exalted Electrical Engineering, who tells him that Shoddy Materials was contracted because their insulation was much cheaper than that from their previous supplier, and it was cheaper because it was known to be not as good as what was used previously, but it is good enough for Tergic Blips. **[Complicating factors:]** The manufacturing specification followed by the Production Department at Exalted Engineering has just been adjusted and approved accordingly by Dusty to allow the use of insulation supplied by Shoddy Materials. Dusty advises Christopher to accept that the reduced performance of the current Tergic Blips is actually adequate and safe under all likely conditions, as otherwise Christopher's employment might be terminated. Christopher concedes that the performance meets the revised specification, but still feels that it is potentially dangerous. **Which of the IEEE code of ethics (if any) should drive the actions of Christopher and Dusty for this situation?**	#1

Students with opportunities to practice demonstrated better recognition of ethical dilemmas (assessed using the Pittsburgh-Mines Engineering Ethics Assessment Rubric) in the end-of-module problems compared to their peers who did not.

Pittsburgh-Mine ratings of students recognition of ethical dilemmas for ECE 121 end-of-module problems in ECE 121

Group	Module 1 (Electrical Safety)	Module 2 (Conflict Minerals)	Module 3 (Wearable Sensors)
Year 1	2.811 (N=114)	2.027 (N=103)	2.700 (N=114)
Year 2	3.131 (N=109)	2.514 (N=110)	2.780 (N=112)
Difference (Year2-Year1)	**+0.32**	**+0.487**	**+0.080**

Does increasing practice opportunities to identify ethical concerns increase first-year electrical/computer engineering student performance for this skill? (YES!)

Student selections of IEEE code of ethic for 6 case-studies in ECE 121

Case	Students (Responses)	Percentage of Student Answers for each IEEE Code of Ethic for each case										
		#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	None
1	113 (127)	**77.2**	0	3.9	1.6	6.3	2.4	0	0.8	0	7.9	0
2	114 (156)	**51**	0	7.2	9.2	7.8	19	0.7	0	0	5.2	0
3	115 (211)	12	1.7	12	20.2	**36.5**	2.6	0.9	0	3	1.7	0
4	112 (242)	9.1	3.7	10.3	2.5	16.9	8.7	2.9	1.2	11.2	6.2	**27.3**
5	109 (107)	1.9	0	2.8	3.7	**89.7**	0.9	0	0	0	0	0.9
6	112 (145)	4.1	0.7	**74.5**	9	3.4	2.1	1.4	0	0	0	4.8

Results

Overall, 3 of 6 cases had >75% student submissions aligning with the appropriate IEEE code of ethic, 1 case had approximately 50%, and 2 cases had less than 50%. The cases where students struggled tended to be when multiple codes could be applied and/or where language did not align perfectly with the IEEE code of conduct.

Most importantly, students in Year two, on average, demonstrated better recognition of ethical dilemmas in all 3 end-of-module problems compared to their peers in Year one.

When submissions for the 6-case studies indicated students struggled to identify the IEEE code of conduct most relevant (**bolded**) they tended to be for cases when multiple codes could be applied and/or where language did not align perfectly with the IEEE code of conduct.

THE UNIVERSITY OF ALABAMA®

Acknowledgement

This material is based upon work supported by the National Science Foundation under Grant No. 2020560. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.