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Ulla-Talvikki Anniina VIRTÄ

Tampere University, Finland, ulla-talvikki.virta@tuni.fi

Hannu-Matti JÄRVINEN

Tampere University, Finland, hannu-matti.jarvinen@tuni.fi

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Effects of engineering education on students' ethical attitudes

Ulla-Talvikki Virta

Tampere University

Finland

ORCID 0000-0001-5224-3504

Hannu-Matti Järvinen

Tampere University

Finland

ORCID 0000-0003-0047-2051

ABSTRACT

Integrating teaching about ethics in engineering degree has challenges: Teachers focused on the degree core topics may lack the expertise to handle the ethics, and teachers with an ethics background may struggle to connect the ethics teaching to the field-specific issues. In addition, a portion of the students themselves may consider the non-core topic to be unnecessary or demotivating, which poses further challenges for the teaching. In the paper, we explore the ethical attitudes of students based on a survey conducted on information technology, electrical engineering and computer sciences students at our university.

The survey received 224 responses. We compare the attitudes of students depending on their progress in their studies and whether they have had any ethics teaching included in their studies. In addition, we discuss the students' attitudes compared to the ethical attitudes of the graduated engineers from a survey of members of a national engineering association.

As the goal is to understand how to better integrate ethics teaching into education, we also discuss the students' views on how the teaching should be integrated and if students' previous encounters with ethics teaching affect their opinion on the matter.

Conference Key areas: Sustainability and ethics. Engineering curriculum design.

Keywords: engineering ethics, ethical attitudes

1 INTRODUCTION

In digitizing societies, professionals of information technology, computer sciences or electrical engineering are going to be working with many of the core components of the society, that can range from tools that facilitate democracy to devices that monitor our homes or algorithms and artificial intelligence that decide what kind of news or entertainment we see. That lays heavy responsibility for the engineers and other professionals of the fields to be able to consider the ethical consequences of the solutions that are made.

That in turn challenges the engineering education to provide sufficient teaching that can support the future engineers. To better understand what is needed from the education, it is important to know how the current education affects the students' ethical attitudes.

Students' attitudes towards ethics teaching are also an interesting question. It is difficult to motivate a student, who has pre-decided that the topic is waste of time. To that end, we want to know what are the current opinions of students towards ethics teaching and how they think it should be included in curriculum.

In this paper, we discuss students' ethical attitudes and views towards different kinds of ethics teaching based on survey conducted to information technology, electrical engineering and computer sciences students at our university. The survey received 224 responses, of whom 46% recalled having had received ethics teaching during their studies thus far. Compared to our earlier study (Virta and Järvinen 2021) regarding graduated engineers of varying fields where 70% of respondents did not recall having ethics discussed during their studies, it is better, but still surprisingly low.

The research questions of this paper are:

1. Does the received teaching that discussed ethical issues affect their ethical attitudes?
2. How does students' progression in studies affect their ethical attitudes?
3. How ethical issues have been included in their studies and how students wish they would be included?
4. Do the ethical attitudes of students differ from the attitudes of graduated engineers?

The paper is structured as follows: Section 2 discusses background of ethics teaching. Section 3 discusses the methodology and the survey in more detail, and results are presented in section 4. Conclusion and discussion are in section 5.

2 Related work

Teaching ethics for engineers is multifaceted issue of what and how to teach and if the teaching has the desired effect. There are several ways to include the teaching into curricula. Colby and Sullivan, for example, present three main possibilities: stand-alone course, a brief discussion about ethics whenever ethical issues arise naturally during the course, or few hour-long modules to include into subject courses (Colby and Sullivan 2008). Stand-alone courses are strongly advocated by Unger, as they provide comprehensive view on ethics (Unger 2005). On the other hand, as Colby and Sullivan point out, if stand-alone courses are so called general philosophy courses that focus on ethical concepts, students may not know how to utilize that knowledge on the situations they encounter in work (Colby and Sullivan 2008). More so, Bairaktarova and Woodcock argue that ethical behavior does not always follow from ethical awareness (Bairaktarova and Woodcock 2017).

On ethical attitudes, in (Borkowski and Ugras 1992) Borkowski and Ugras discuss in context of accounting students the difference that age, experience and gender have on ethical attitudes. On engineering side, Balakrishnan and Tarlochan conducted an evaluation of near

graduate students socio-ethical attitudes, noting also that students had difficulties to connect their current ethics teaching to relevant engineering questions (Balakrishnan and Tarlochan 2015).

3 METHODOLOGY

The survey was directed at students of information technology, electrical engineering and computer science at our university. It was held as an online survey and distributed via three email lists, each consisting of the target field students.

The survey contained five sections, three of them common to all respondents and two optional based on given answers. The common sections included demographic questions, the ethical attitudes question set and how ethical topics had been handled in their studies thus far. The optional sections asked if the students had encountered ethically questionable situations during studies or work. If they had, the optional sections asked for details about the situations.

Demographic questions included: Year of birth, gender, the total amount of study credits, start year of studies, the field of study, if they were studying at bachelor or masters level and how much they had field-specific work experience.

The ethical attitudes question set follows the ethical sensitivity scale by K. Tirri and P. Nokelainen (Tirri and Nokelainen 2012). Our survey used 14 questions, half of the original set, to match the earlier survey for members of a national academic engineers' association. The question selection was discussed further in (Virta and Järvinen 2020). List 3 enumerates the questions for further use in this paper. The students were asked to evaluate these claims with scale of 1-5, where five was to fully agree with the claim and one to fully disagree.

1. When I'm working on ethical problems, I consider the impact of my decisions on other people.
2. I try to consider other peoples' needs, even in situations concerning my own benefits.
3. I recognize my own bias when I take a stand on ethical issues.
4. I realize that I am tied to certain prejudices when I assess ethical issues.
5. I try to control my own prejudices when making ethical evaluations.
6. When I am resolving ethical problems, I try to take a position evolving out of my own social status.
7. I contemplate on the consequences of my actions when making ethical decisions.
8. I ponder on different alternatives when aiming at the best possible solution to an ethically problematic situation.
9. I am able to create many alternative ways to act when I face ethical problems in my life.
10. I believe there are several right solutions to ethical problems.
11. I notice that there are ethical issues involved in human interaction.
12. I see a lot of ethical problems around me.
13. I am aware of the ethical issues I face at work.
14. I am better than other people in recognizing new and current ethical problems.

The last common section queried if ethical topics had been discussed during their studies. Students could select among positive or negative options. Positive options included having participated in a dedicated course, ethics being discussed on multiple or singular courses when pertinent to the course's main topic, or recalling passing mentions. Negative options included ethics not having been discussed in studies or being unsure if ethics had been discussed.

Students, who had received any kind of ethics-related teaching were also asked to explain what kind of courses, and how ethics was discussed. Lastly, the students were asked to sort

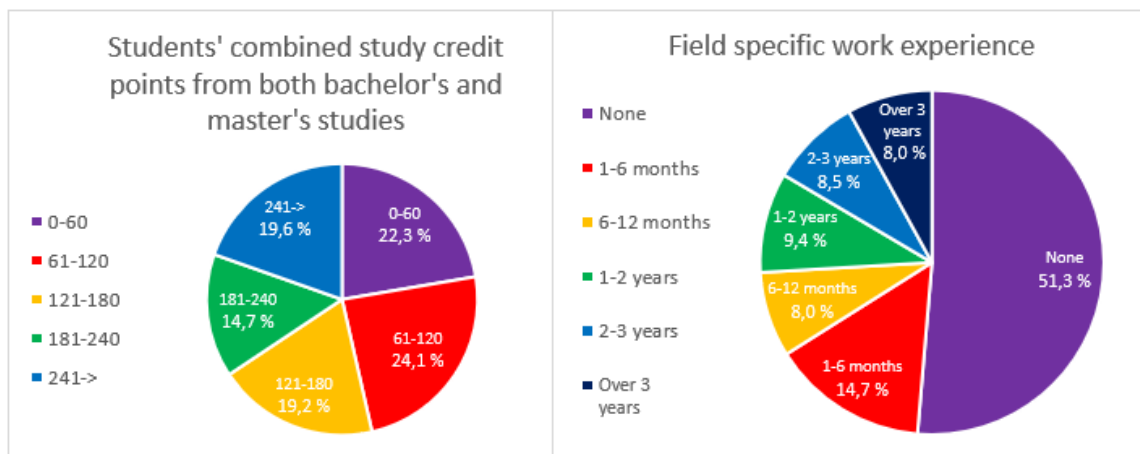


Figure 1: Overview of the study credits and field-specific work experience among respondents.

between four options for ethics teaching from their favourite to least favourite option. The options were: Separate mandatory course, Separate voluntary course, During multiple courses and combined to the core topic, and Not necessary.

Last two sections enquired if the students had encountered ethically questionable situations in either their studies or field specific work life. Students who had encountered such situations were offered possibility to elaborate about the cases. In addition, they were asked if they had felt the need to intervene, if they had done so and why they had or had not intervened.

4 RESULTS

In this chapter we discuss first the overview of respondent' background and then the effect of different factors to students' ethical attitudes are explored.

4.1 Respondents' background

The survey received responses from 224 students and of those, 64% were working on a bachelor's degree and 36% on a master's degree. The start year of studies ranged from 1989 to 2022, however 90% of the respondents had started their studies between 2015 and 2022.

Students selected their acquired study credits from five categories that correspond to the expected progression through years one to five. These categories were 0-60 study credits, 61-120sc, 121-180sc, 181-240sc and over 241 study credits. However, it should be noted that each student may have individual differences on how the accumulated credits and actual study years correspond to each other.

The progression of studies as well as field specific work experience varied between respondents, details are presented in Figure 1. Most (83%) respondents without field-specific work experience were studying for bachelor's degree with varying amount of study credits. The gender division of respondents was: 29% women, 69% men, 2% others or do not wish to answer.

4.2 Received ethics teaching

Survey charted if the respondents had received any kind of teaching in ethics during their studies. On high level, if student had picked any of the 'Positive'-options (discussed in chapter 3), they were considered to having received teaching in ethics despite any other selection they made. If they picked only 'Negative' options, they were counted as not having received ethics teaching. 46% of the students said they had received some teaching in ethics.

Unsurprisingly, the lowest study credits bracket had the least amount of students who had

received ethics teaching. In further brackets, however, the increase in study credits did not automatically mean higher percentage of received ethics teaching. The differences between study fields were high, which does not look good for our engineering tracks: 76% of computer science (not an engineering track) students reported having received ethics teaching compared to 38% of information technology and 25% of electrical engineering students.

To understand what kind of ethics teaching students had received, they were also asked to shortly describe what course(s) had included ethics and how. It is important to understand if students, who had received teaching, had personally selected more ethics related courses or if the teaching was included as a part of the regular curriculum. As the students were allowed to write freely, it was not always possible to connect the response to a specific course. It was also possible that students mentioned courses from previous studies or different universities.

The single most common mention was an introductory course to computer sciences, a mandatory course in the computer sciences programme. Bit less than one in five mentioned this was their source of ethics teaching, and if counting all mentions of introductory-type courses for programmes, those were present in 23% of the descriptions.

The second largest factor was different courses in Human-Technology Interaction, mentioned in 13% of descriptions and cyber security courses (mentioned in 10%). In approximate 5-6% ball park were mentions of machine learning courses, usability or UX-design courses and course about information technology and society. There were also singular mentions of different subject matter courses that had touched ethics. These could be, for example, courses about electronics or software engineering.

Students, who had taken specific courses in ethics were not common, but there were few mentions of for example minor studies in philosophy. Different ethics courses, which included mentions of general ethics courses but also ethics with more narrow focus such as business ethics or ethics of artificial intelligence, in combined were mentioned in 6% of the descriptions. From this we can see that ethics focused electives were not significant factor in the received ethics teaching, most students encountered it either on the mandatory introductory course or during their subject matter courses.

4.3 Ethics teaching and attitudes

To evaluate the effects of teaching on the ethical attitudes, the students were divided to five different cohorts based on the selected teaching type. If a student had picked multiple options (i.e. 'having participated in separate course on ethics' and 'ethics had been touched shortly'), the student was counted under the option that provided highest involvement with ethics.

Figure 2 gives an overview of how the attitude averages on different questions (questions 1-14) are affected depending on what kind of teaching students had received. On all the questions, students who had not received any teaching scored lower than students who had participated on separate course on ethics. Ethics discussed during multiple courses-option settles between the extremities on most questions. However, cases where ethics discussion had been encountered on one course or touched only shortly, the overall trend did not improve much compared to not having received teaching. This indicates that we cannot expect singular lecture or passing mentions to provide enough ethics teaching to see improvements in students.

4.4 Ethical attitudes in comparison to study progression or gender

To see what other factors might affect students' ethical attitudes, we also compared how the general progression in studies as well as gender reflected in the attitudes. To that purpose, first we compared the averages on the attitude scales for the five different study credit cohorts. With the fourteen questions, individual questions had different trends in how the averages

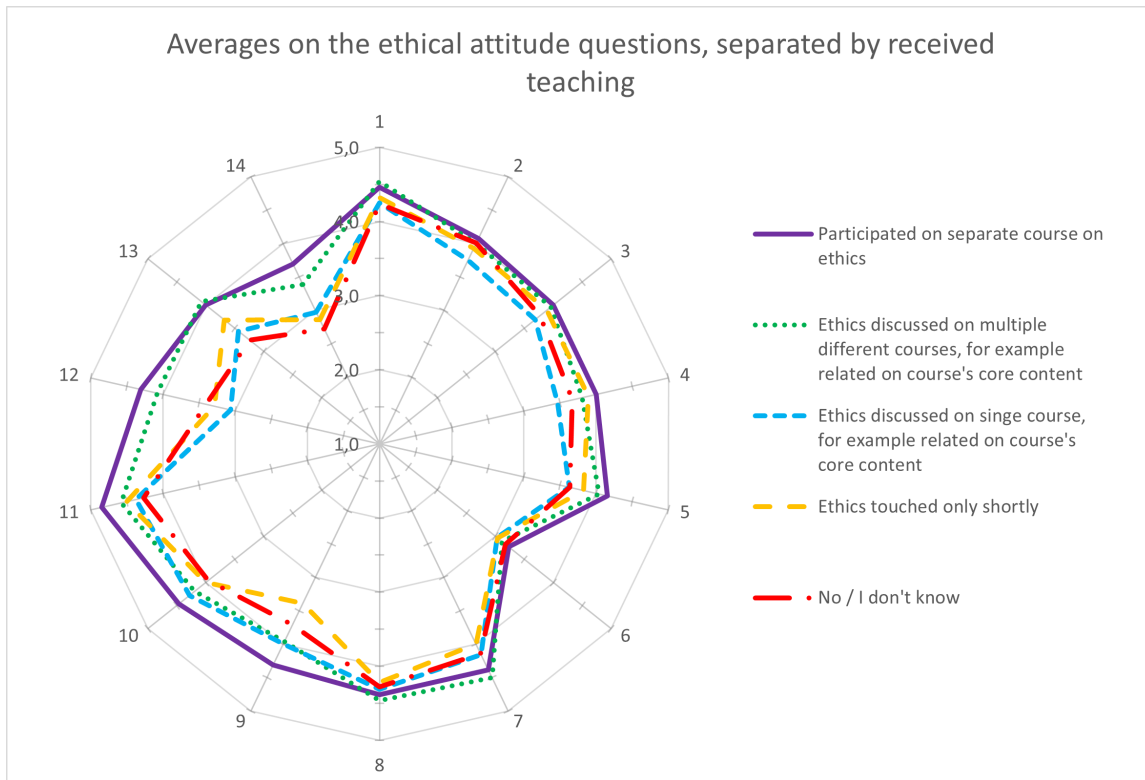


Figure 2: Overview of differences between ethical attitudes depending on the style of teaching received by student. Question numbering corresponds to list 3.

behaved between the study credit cohorts, but one trend was for the attitudes to be highest during the first year, then drop towards mid studies and raise back for the last year.

In 13 of the 14 questions, the 0-60sc cohort had higher averages than the cohort with over 240scs. Of those, in ten questions the 0-60sc cohort had highest average of all the cohorts. Not all the differences were statistically significant, but figure 3 shows the averages of the 0-60sc cohort and how much it differs from 121-180sc and over 241scs cohorts. Highlighted in green are the p-values where the difference was statistically significant.

This trend of fresh students having higher average attitudes continues even when compared to data surveyed from members of national engineering association along the study (Virta and Järvinen 2021). On majority of questions the 0-60 study credits cohort scored higher averages than the the graduated engineers already in workforce or retirement. On the questions 4, 8

Question	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
Attitude averages of 0-60sc cohort	4,58	4,24	4,04	3,80	4,08	3,16	4,52	4,55	4,02	4,26	4,60	3,49	3,37	2,96
Average difference to 121-180sc cohort	0,51	0,44	0,23	0,13	0,56	0,18	0,54	0,50	0,31	0,19	0,41	0,20	-0,01	0,20
p-value	0,007	0,025	0,216	0,522	0,023	0,410	0,003	0,003	0,087	0,365	0,028	0,439	0,955	0,328
Average difference to 241sc-> cohort	0,40	0,26	0,40	0,32	0,60	0,11	0,52	0,35	0,16	0,19	0,12	0,10	-0,13	0,07
p-value	0,008	0,081	0,034	0,132	0,004	0,592	0,005	0,020	0,405	0,377	0,415	0,679	0,582	0,708

Figure 3: Attitude average differences between early and mid or late studies with highlights on p-values smaller than 0.05.

and 12 the difference was statistically significant. However, the averages from engineering association members on most questions were higher than the averages of cohort 241 and over. Difference was statistically significant on questions 1, 2, 5, and 7. From this it seems that after graduation, the attitudes get closer to the attitudes from fresher students. The question where both older student and TEK members scored higher was question 13: 'I am aware of the ethical issues I face at work.' These results are in line with findings from (Borkowski and Ugras 1992), where freshmen and juniors were found to be more justice-oriented compared to the students working on their Master of Business Administration degree.

On all fourteen questions the average for men was lower than that of women's. However, on only two questions (Questions 5 and 12) the difference was statistically significant. On questions 3, 4, 6 and 8 the difference was so small (under 0.05 points on the one-to-five scale) that the attitudes averages could be considered to be on same level.

4.5 Students' views on integrating ethics teaching in curriculum

Students were asked to rank four high level options of ethics teaching integration with scale 1 (most preferred) to 4 (least preferred). The options were: 1. Separate and mandatory course. 2. Separate but voluntary course. 3. Included in several courses, combined with core topic (CT) 4. Not necessary (to include). Table 1 gives the weighted averages for each option among all respondents, those who had received teaching and those who had not received teaching. On average, the third option was preferred by all, regardless of received teaching.

Table 1: Rank averages of ethics teaching options from 1 (favorite option) to 4 (least favorite option)

Option	All	Yes teaching	No teaching
1. Separate and mandatory course	2.87	2.69	3.03
2. Separate but voluntary course	2.04	2.19	1.91
3. Included in several courses, combined with CT	1.79	1.73	1.84
4. Not necessary	3.28	3.36	3.22

Figure 4 shows summary of how the received teaching affected the students' preferences for teaching methods. There are few places of interest. The students who had received ethics teaching selected the separate and mandatory course as their first pick (16,7%) more often than those who had not received teaching (7,4%). In addition, the students with previous ethics teaching also selected option 3 more often, resulting in situation where the option 2, which is the only one leaving the ethics teaching on voluntary basis only, was selected as the first pick by 19,6% of those who had received ethics teaching and by 32% of those who had not received ethics teaching.

Received teaching did not make difference in how large portion of students selected "Not necessary" as their first pick. Both groups selected this in slightly under 12% of answers. On the flip side, "Not necessary" option as the last pick was more popular among those who had received teaching (61,8%) than those who had not (52,5%).

In addition, students were allowed to offer other ideas on how to teach ethics and 20% of students gave suggestions. The answers were categorized based on the type of suggestion they included. One of the most popular ones was request for concrete examples, present in 23% of suggestions. Nine percent of the suggestions also included sentiments towards including experts as guest lectures or additional education for the core content lecturers. While this is minor faction of all respondents, it is still worthwhile to note that students may also evaluate if the core content lecturer is credible teacher on the subject of ethics.

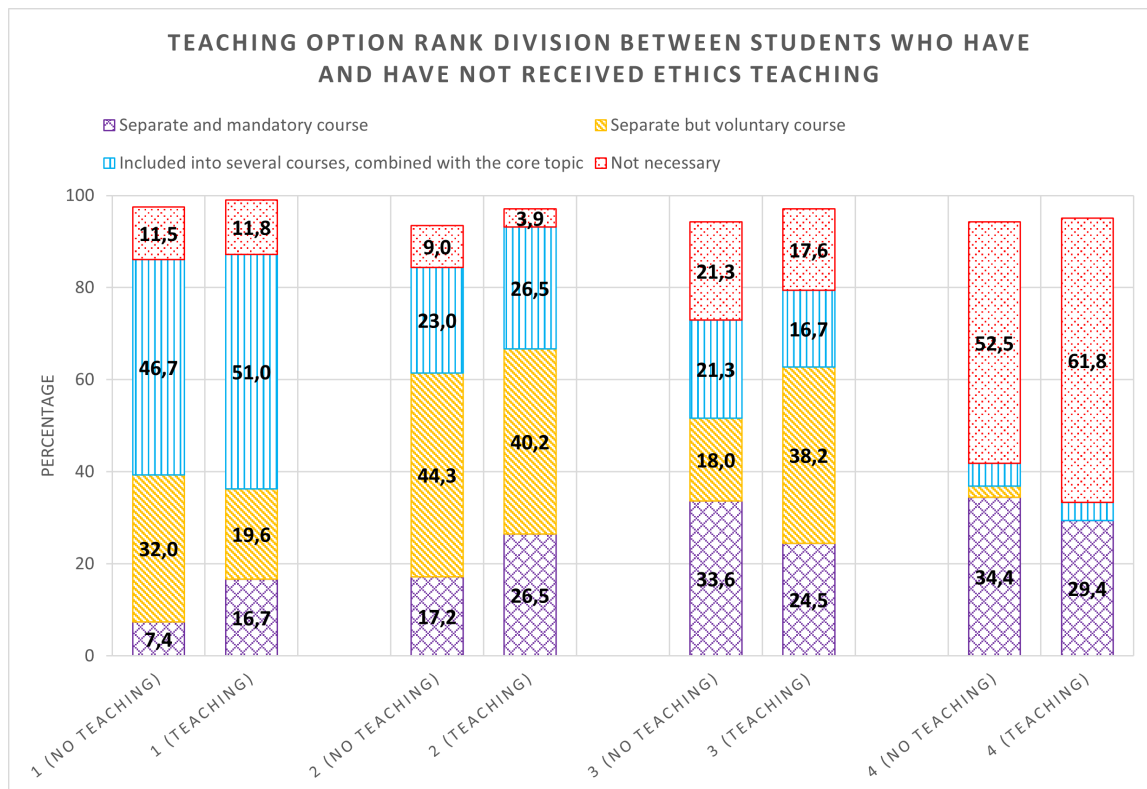


Figure 4: Overview of how students, who had received teaching and who had not, ranked different teaching options from 1 (Favorite) to 4 (Least favorite).

5 DISCUSSION

Students, who had received higher amounts of ethics teaching did, on average, score better on the ethical attitude questions compared to those who had not received teaching or had received it in slight amounts only. Merely studying in university does not guarantee improvement, as we can see from the peculiar behavior of the attitudes in relation to the study progression.

For ethics teaching in higher education, the positive finding is, that most students consider the inclusion of ethics necessary. Its integration into core topic courses was the most popular option from students' point of view. As we hypothesized, a separate and mandatory course was not very popular. It is, however, interesting to note that students who had received ethics teaching were more open to its inclusion in the curriculum, even as a mandatory part.

This opens up the question of which part of the studies the ethics should be taught and how it should be taught depending on how far the students are in their studies. Now the introductory courses were the biggest singular source of ethics teaching, but at that point, students do not yet have a comprehensive understanding of the field they are studying and the potential ethical questions that can rise within it. As the received ethics teaching did make students more receptive to further education in the topic, one possible solution could be to use the integration approach during bachelor-level studies, but provide an ethics-specific course during master's studies that could venture into general ethics as well as field-specific examples. How to balance general ethics teaching with field-specific aspects is a potential topic for future study.

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