Ethics in Computing Education

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**ABSTRACT**

Understanding ethics in computer science and software engineering has become an important part of the profession as evidenced by the focus on developing ethical thinking and awareness in university students. This article reviews pedagogical approaches to teaching ethics, in particular the importance of encouraging students to think ethically through group discussion on personally relevant topics. Efforts of the last several decades had been successful in getting institutions to teach ethics to students in computing disciplines. However there are some institutions that have yet to implement some form of ethical education that could benefit from training in this area.

**Categories and Subject Descriptors**

K.4.1 [**Computers and Society**]: Public Policy Issues - *ethics*

K.3.2 [**Computers and Education**]: Computer and Information Science Education - *computer* *science education, curriculum*

**General Terms**

Management, Security, Human Factors, Legal Aspects

**Keywords**

Ethics, Education.

# INTRODUCTION

The use of computing technologies has become an integral part of modern societies and professionals working in the industry may face ethical issues affecting individuals, organizations and wider society [[8](#_ENREF_8)]. There are many potential issues that can be encountered and professionals may have to weigh competing and sometimes conflicting demands [[1](#_ENREF_1)]. For example, what should someone do if they believe there are security risks with a product but management is content to make it available to clients because it is 'secure enough'? Or a question that is currently more topical, how should an employee react to knowledge of widespread privacy breaches their organization? For developers of new technologies, there are many issues that can arise without precedent, such as who is to blame when autonomous vehicles are involved in an accident? Should military robots be allowed to make firing decisions without human supervision? These are samples from a wide range of issues that a rapidly changing field must face. Students in computing disciplines should be aware of what they could expect in the workforce as well as how to deal with such issues [[14](#_ENREF_14)].

This article reviews some of the research on education in computing ethics. Section 1 summarizes some of the ideas behind popular pedagogical approaches and then moves on to the results of their applications in undergraduate computer science and software engineering programmes. Section 2 reviews the topic of professional and what is expected of a profession with regards to ethical conduct. Section 3 introduces ethical codes that have been developed by computing associations and some of the issues that surround them. Section 4 reviews approaches to teaching ethics in computer science, and Section 5 looks at recent surveys of the state of computing ethics in higher-level education.

# PROFESSIONAL ETHICS

Several authors have suggested that computing disciplines should teach ethics as part of their curriculum, as computing professionals interact with and develop technologies that increasingly have effects on society as a whole [[8](#_ENREF_8); [14](#_ENREF_14)]. One topic often discussed is what it means for computer science to be considered a profession, and whether the computing industry should model practices of other more established professions such as medicine, accounting and law [[12](#_ENREF_12)]. Benveniste [[3](#_ENREF_3)] suggests that professions have several elements in common, such as the application of advanced skills and maintaining a code of ethics. Many of these also apply to the computing industry [[8](#_ENREF_8)]. One of the key elements of a profession that is not commonly seen in the computing industry is formal testing and admission of members to an association. While institutes such as the Association for Computing Machinery (ACM), the Institute of Electrical and Electronics Engineers (IEEE) and the British Computing Society (BCS) exist and maintain codes of conduct and ethics, membership is typically voluntary. Consequently the value of understanding and adhering to a code of ethics is not a priority in the workplace or in education [[8](#_ENREF_8)]. In other fields such as medicine, for example, breach of ethics can amount to malpractice and have serious consequences for the individual and their organization [[12](#_ENREF_12)]. Because of this, training programs and membership examinations for medical professionals prioritise teaching and understanding ethical codes. While similar breaches of ethics can occur in the computing industry, in many institutions ethical codes are of secondary importance to technical issues [[8](#_ENREF_8)]. Little et. al. [[8](#_ENREF_8)] argue that because new graduates will go on to have a significant impact on society and can face a range of ethical dilemmas in the workplace, ethics should be incorporated as part of undergraduate training programmes

# ETHICAL CODES IN COMPUTING

Ethical codes of conduct have been developed by prominent computing associations such as the ACM, IEEE and BCS. In addition to outlining expected behaviours and qualities of their members, they form a basis for teaching students about expected behaviours in the workplace [[12](#_ENREF_12)]. One critique of such codes is that they are ambiguous. While people can generally agree on the more general principles contained in codes of ethics, for example avoiding harm to others, it is not always clear how this should be done. This is particularly important when dealing with complex systems and development processes [[12](#_ENREF_12)]. One popular example of this is the case of the Therac-25, a device for providing controlled bursts of radiation in therapy [[10](#_ENREF_10)]. A bug in the control software caused lethal doses of radiation to be administered to two patients, who subsequently died. While it can be argued that more extensive testing should have been done, it is not always clear who is responsible for ensuring appropriate testing especially when larger development teams are involved.

Another issue that has been raised regarding ethical codes is that there is no clear sense of moral priority in cases when multiple stakeholders are involved or when ethical guidelines conflict [[4](#_ENREF_4)]. Computing professionals are likely to have to balance responsibilities to employers, clients, other professionals and society which can put them into difficult situations. Preston [[11](#_ENREF_11)] cites an example where a student intern completing the work placement component of an undergraduate degree was put in a role providing both the specifications and the tests for a safety critical system. This would be considered a conflict of interest, as there is a tendency to 'test to pass' when these roles are performed by the same individual. The company presented this product to clients as well tested and criticized the student for questioning the company's testing standards. The authors [[11](#_ENREF_11)] state that situations like this, where companies would take advantage of students inexperience, were quite common.

How to navigate complex situations according to codes of ethics is not always clear [[1](#_ENREF_1)]. Fortunately organizations such as the IEEE provide well documented processes for supporting their members when faced with difficult ethical issues [[12](#_ENREF_12)]. Rosenberg [[12](#_ENREF_12)] suggests that the difficulty of drafting codes of ethics is one of the reasons why they are rarely updated. This can be problematic if they are to be used as a guide for current students and professionals given the rate of change in the industry [[14](#_ENREF_14)]. Rosenberg recommends that associations need to provide more than just their code of ethics, it is imperative that they engage with the community, speak to students and inform them about potential issues they can encounter, along with what support is available. Despite the issues around codes of ethics in computing, they are considered a very good starting point for ethical discussions in introductory courses in computing [[11](#_ENREF_11)].

# TEACHING COMPUTING ETHICS

Institutions focus heavily on technical skills in their curricula in order to ensure that new graduates can meet the expectations of employers. However there has been a growing sense that non-technical skills such as the ability to communicate well, work as part of a team and understanding the ethical implications of technology are equally important [[8](#_ENREF_8)]. While there is general acceptance that students in computing disciplines should be exposed to ethics in training, there is uncertainty about how to achieve this. It has been suggested that computing instructors in many cases are not qualified to teach ethics [[9](#_ENREF_9)]. Some instructors also believe that the classroom is not an appropriate place to teach ethics, because ethical ideas are based on societal norms and there is concern about indoctrinating students [[11](#_ENREF_11)]. Opponents of this type of ethical relativism argue that there are some universal moral standards despite differences between cultures in their practices and beliefs [[14](#_ENREF_14)]. Other concerns raised are more practical and centre around how to fit extra material into existing programmes. The general attitude from researchers who have successfully taught ethics in their courses is that it should be integrated alongside technical material wherever possible [[4](#_ENREF_4); [7](#_ENREF_7)].

One of the main barriers to the adoption of ethics as part of computing programmes is the lack of guidance and training material for instructors, most notably in earlier revisions the ACM/IEEE Computing Curricula (CC). The ImpactCS project produced three reports to address this issue, outlining an addition unit to the CC called "Ethical and Social Impacts of Computing" [[9](#_ENREF_9)]. The central recommendation of the ImpactCS report is that ethical and social issues cannot be treated separately from the technical aspects of computing. Modules outlined in the CC should be integrated as much as possible into modules from other units, as opposed to being covered in a separate course [[9](#_ENREF_9)]. The authors of the report argue that computing ethics is an interdisciplinary topic that includes elements from computing, philosophy and social science. Since students cannot be expected to take additional classes on these subjects, lessons on ethical reasoning should be integrated into the curriculum [[9](#_ENREF_9)].

The authors of the ImpactCS report provide the theoretical foundation for a staged approach to teaching ethics. They cite evidence that people progress through stages in their understanding of ethics and can only progress onto the next stage after having fully completed the previous one [[9](#_ENREF_9)]. The three stages are: becoming aware of the ethical issue, developing the ability to evaluate ethical situations, and becoming responsible for taking action. The progression of students through these developmental stages in ethical thinking can be accomplished through the following key recommendations.

The first is to introduce students to ethical thinking in introductory programming courses. The authors argue that the focus here should be on issues relevant to individual students, such as copyright and privacy. The second is to continue with some form of discussion around ethical issues in most courses, stemming from existing course content. For example, there could be a discussion on the ethical issues and potential consequences of unauthorized access in a security module by looking at case studies on the issue. Thirdly, instructors need to believe that what they are teaching with regards to ethics is important and have the ability to engage and maintain student interest. The final recommendation is in regards to design of the curriculum. This involves planning content carefully to avoid too much overlap between courses, while allowing coverage of a range of ethical issues [[9](#_ENREF_9)]. The ImpactCS report argues that assessment on ethical material is essential to engage students and should be included in graded assignments and exam questions. While the authors acknowledge the difficulty in accommodating ethical material into courses, they expect instructors to make an effort and to be supported through ongoing training.

One critique of the ImpactCS approach is that it not clear from the report how successful this approach to teaching ethical teaching would be. Preston [[11](#_ENREF_11)] argues that students have failed to engage with the material, having no similar experiences to relate to. The author suggests that the focus should not be on assuming the role of someone in an ethical dilemma through case studies, but rather to build on student' on experiences. This could be done through group discussion rather than formal lecturing. The rationale behind using group work is based on research which shows that the development of moral reasoning is more effective when people discuss issues in groups, particularly when there are a range of existing moral reasoning abilities in the group [[11](#_ENREF_11)]. While Preston argues against the use of case studies, there is some agreement with other issues raised in the report, namely that ethical education needs to be integrated alongside technical education, and that ethical education is interdisciplinary in nature.

In contrast to the findings by Preston [[11](#_ENREF_11)], Gerhardt [[7](#_ENREF_7)] has found the use of case studies to be successful in establishing awareness of ethical issues in undergraduate students. Gerhardt focussed on creating fun and engaging content to get students thinking about ethical issues in a systems analysis and design course. Like Little [[8](#_ENREF_8)], Gerhardt believes that students should come away from their studies with more than just technical experience, but experience in how to make ethical judgments as well. As suggested in [[4](#_ENREF_4)] the issue from an instructors view is what approach to take in teaching these skills. Gerhardt used the fictitious "Case of the Killer Robot" [[5](#_ENREF_5)], a case study of a factory robot that decapitates a man. This is presented as a series of newspaper articles, and interviews written with both seriousness and humour. Students were asked to read an article every other week and write short reviews on them. In addition, they answered some specific questions on each article. The articles were then discussed in class, sometimes resulting in interesting or controversial views being expressed. Questionnaires were used at the start and the end of the course to evaluate the effectiveness of this approach. The results were positive, with students reporting an increased understanding of ethical issues and a increased desire to maintain professional codes of ethics [[7](#_ENREF_7)].

Another successful approach based on the use of case studies has been reported by Dick [[4](#_ENREF_4)]. As part of their coursework, students were placed into groups and asked to develop case studies, which may be fictional, but could have real consequences to them. Senior management from leading computing organizations were invited to attend a presentation by the students on their case study followed by informal discussion with the management teams. The authors found that this approach to developing ethical awareness worked well as students were asked to consider their own circumstances and how they would react to being in a situation relevant to them. This approach was also successful due to the presence of the management teams which gave students an understanding of how these issues would be handled in the workplace.. The author also claims that students developed an understanding of ethics based on an internal sense of correct behaviour, as opposed to relying on codes of conduct which are not always clear.

These examples of integrating ethics within a curriculum shows that aspects of the ImpactCS report on teaching ethics are effective. In contrast to Preston's claim that case studies are not effective, the reported success of Gerhardt [[7](#_ENREF_7)] and Dick [[4](#_ENREF_4)] suggests that case studies themselves may not be the issue, but rather the context in which they are used is important. It also matters how students are engaged. Gerhardt used an entertaining example with regular assessment and opportunity for class discussion. Dick required students to envisage a situation important to them, and provided opportunities for the students to interact with industry professionals who could validate their ideas. Both of these examples involved the use of group discussion which also lends weight to the claim that group work is an effective way to teach ethics [[11](#_ENREF_11)].

The view that cooperation with industry companies is beneficial is also supported by Little [[8](#_ENREF_8)], who suggests that collaboration in this way helps integrate professional issues into computing courses. Dick [[4](#_ENREF_4)] also suggests that people in management positions modelling the expected behaviour of IT professionals works better than creating and attempting to abide by formal codes, which can be contradictory or become outdated relatively quickly. Rosenberg [[12](#_ENREF_12)], provides support for this, noting the difficulty in developing codes of ethics as the reason why they are rarely updated. While Dick reports successful feedback from both students and computing professionals attending the seminars, the authors are careful to note that further research needs to be done to judge the difference between the ethical reasoning abilities of students involved in the program compared with those that are not [[4](#_ENREF_4)].

In addition to Preston's [[11](#_ENREF_11)] findings on the effectiveness of group discussions, the author reported some success with using external speakers to stimulate discussion in a course designed on ethics and societal impacts. The course includes a range of topics such as computer crime, whistle blowing, privacy and politics. External speakers are invited to an open session which includes voluntary attendance from students as well as the local community. The speakers give informal talks on topical issues such as copyright and whistleblowing. Some talks were found to generate high levels of interest from the students while others did not, even when the same speaker was invited back.. The authors concluded that while these talks can be valuable to students, predicting which talks would be the most rewarding was difficult.

Another aspect to the course discussed by Preston is a tutorial series on whistleblowing [[11](#_ENREF_11)]. These sessions aim to teach students to identify actions in the workplace that could be significant. Students were found to achieve well academically in the course but did not seem to be as responsive as when attending some of the voluntary open sessions described above. Since the introduction of the course on social aspects of computing, the author has found an increased rate of false positive reports on unethical practice from students interning at local organizations.. The author notes that it is encouraging that students are thinking more about ethical issues in the workplace, however some were found to go to extreme lengths over benign actions by their host company. This included reporting them to newspapers and then avoiding contact with their tutors in the programme to preserve secrecy about their actions.

Fuse et. al. [[6](#_ENREF_6)] found that in some institutions, workshops on ethics could be replaced with shorter, more frequent sessions where live action video clips of students facing technical and ethical issues were played. While these were used to educate students on campus in general and not primarily for developing ethical thinking in computing students, they were found to be an engaging format because of their brevity and the range of topics covered. Subjects in the clips were chosen to be relevant to ordinary students and included issues such as copyright, privacy and computer crime. In earlier work on the use of video clips to teach computing ethics, Yamanoue et. al. [[16](#_ENREF_16)] suggests that this type of material can replace more traditional lectures, with clips being shown to start discussion in class and form the basis on graded assignments on the subject covered. Although the videos were generally appreciated by students at institutions where ethical components are compulsory, it is not clear whether the students developed their ability to reason about ethical problems. The video series used in [[6](#_ENREF_6); [16](#_ENREF_16)] are potentially a good resource to introduce undergraduate students in their first year to ethical issues of relevance to them.

A more experimental method in teaching ethics has been tried by Bekir et. al. [[2](#_ENREF_2)] who adapted "The Ethics Challenge", a board game developed by Lockheed Martin Corporation, for their in-house ethics training for use in an electrical and computer engineering course. The game consists of 50 hypothetical cases representing ethical dilemmas on topics such as conflicts of interest, misuse of company assets, responsibility, lying and cheating. Students are grouped into teams, each representing a character from the popular Dilbert comic series. Each team works together to pick the best solution to an ethical dilemma presented by the teacher, explaining why they believe their answer is correct. Teams receive tokens based on the quality of the answer and characters are advanced through the board using their collected tokens. Students were found to be very engaged in group discussions and reported having fun playing the game. The effectiveness of this approach in teaching ethics was measured through a survey administered before and after the activity. Half of the students found that the game changed the way they thought about professional ethics, while seventy percent said that they would volunteer to repeat the game with different scenarios. These findings reinforce the idea that groups discussions are an effective way to develop ethical thinking in students and that using fun activities helps to facilitate engagement and learning [[2](#_ENREF_2)].

Towell et. al. [[15](#_ENREF_15)] has also reported that role-plays are an effective method for teaching ethics to students, citing the adaptation of the "Case of the Killer Robot" into a role play for Masters level students. The author suggests that role plays are effective because they force students to engage actively with material, as opposed to passively reading or listening to material. The novel aspect of having a role play in an engineering course also helps to make the experience more memorable. The role play involves students being divided into groups with each group member assigned a character from the case study. Each group is given an established code of ethics and team members present prosecution and defence cases for the characters. An audience of peers votes on who is responsible in the scenario. Towell et. al. [[15](#_ENREF_15)] claim that this approach has been very successful. This supports the work by Gerhardt [[7](#_ENREF_7)], which found similar success with this case study and Dick [[4](#_ENREF_4)], which reported successful student engagement through discussions and seminars organized by teams using case studies.

# THE STATE OF COMPUTING ETHICS EDUCATION

Surveys of institutions offering computer science programmes have determined to what extent computing ethics is taught at the undergraduate level and what pedagogical approaches are being used [[13](#_ENREF_13); [15](#_ENREF_15)]. An international survey by Towell et. al. [[15](#_ENREF_15)] asked instructors associated with schools offering a degree program in computer science or software engineering to rate thirteen different ethical topics such as confidentiality, conflict of interest, research ethics and whistleblowing, on their importance as well as describe methods used to teach them. The survey also reviewed opinions on whether software engineers and computer scientists should be licensed professionals. Out of over 750 people from 31 countries who received the survey, only 72 (10%) responded to the survey. Respondents were from Australia, Europe, North America and South America. The results showed that the most common method for teaching ethics was through discussions of personal experiences, followed by discussions on codes of ethics or case studies. Real cases from current events were used in many instances and more traditional debate and discussion approaches in the classroom were also used. The most frequently used codes of ethics were those developed by the ACM, IEEE and BCS. Forty percent of the academic respondents said that the teaching of ethics was ignored, while thirty percent said that the teaching of ethics was focused only on a few courses. A further twenty four percent indicated that ethical teaching was delivered in a single course and the remainder said that ethics education was integrated throughout the curriculum. The authors found no significant difference between computer science programmes and software engineering programmes on whether they delivered a course dedicated to ethics. A common concern expressed in the survey was that instructors did not know what material to remove to make room for ethics. The most important topics for ethics rated by the respondents were liability risks, intellectual property, and conflicts of interest. The response to whether software engineering should be a licensed profession was equally divided [[15](#_ENREF_15)].

Spalding et. al. [[13](#_ENREF_13)] performed a similar survey with 700 undergraduate computer science programs in the United States, of which thirty six percent responded. The survey included several questions to assess whether computer ethics was being taught in undergraduate curricula, as well as who teaches the subject and whether training is provided. They also assessed who makes decisions to incorporate the subject into the curriculum and whether there are any reasons for not teaching ethics at all. The authors found that the majority (88%) of computer science programmes teach some form of ethics with most (84.5%) reported ethics being taught by the computer science faculty. In a small numbers of institutions ethics was taught by the philosophy faculty, or as a collaborative effort between various faculties. With regards to who makes the decision to incorporate ethics into the curriculum, just under half (39%) said that a committee faculty were responsible, while a fifth (23%) said that it was up to individual faculty members for their courses. Of those that did not teach ethics at all, most (77%) said that there was no room in the curriculum for computer ethics and the faculty were not trained to teach the subject. The authors conclude that computer ethics education is being taken seriously in undergraduate courses in the United States, but that additional training should be provided to support those that currently do not understand how to integrate ethics alongside existing content [[13](#_ENREF_13)].

# CONCLUSION

The increasing importance of computing in modern society has put pressure on computing professionals to understand ethics related to their discipline. These skills are now essential in order to be successful in this work and minimise potential problems for organizations, peers and the general public. While computer science and software engineering is not currently a licensed profession, there are computing associations that maintain ethical codes of conduct and provide support to professionals who face ethical dilemmas. These ethical codes also serve as a good starting point for students to become familiar with the relevant issues in their field. With the increasing importance of understanding professional ethics in computing, there has been an effort over the last several decades to include more ethics training in undergraduate computer science and software engineering programmes. This effort has largely been successful with surveys from the United States showing a strong uptake in teaching professional ethics and societal impacts of computing. Popular pedagogical approaches to teaching ethics include the use of case studies, role-plays, discussions and games. What is common to successful applications of these methods is engaging students in topics that are relevant to them, allowing them to have fun with the material, and facilitating students ability to see the importance of ethics as part of working as a professional. It is also important to allow students to discuss and develop their views with their peers. In the United States, ethics in computer science is largely taught by computer science faculties over one or more courses. At institutions where computing ethics is not taught the main reason given is a lack of room in the curriculum. There are opportunities to improve uptake on teaching ethics by providing training for instructors so that they can learn how to integrate computing ethics alongside existing material.

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