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Derleme/Review

Ethics education in undergraduate engineering curricula

Mühendislik lisans müfredatlarında etik eğitimi

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Abstract: *Abstract In the 21st century the fast advancement in science and technology necessitates an awareness construction and a standard-setting for ethical behavior and conduct in the society which can only be achieved by education. This education must be given as early as possible. Although it is somewhat late, ethics education at the universities is one of the stages that can be considered with this respect. University students' ability to understand, to deal and to find solutions to different and complex ethical problems and dilemmas must be developed and improved. Thus, an awareness of ethical responsibilities associated with all the professions and an understanding of the impact of different professions' applications and probable solutions of ethical problems must be established by ethics education. Considering many possible methods for ethics education, one that starts from freshman and which is integrated in different courses through the curriculum, and which lasts with case studies in a capstone senior level course, is the one which is recommended. Basing also on the results of the Middle East Technical University-Ethics Education Committee's study on ethics education, the duration for the different teaching tools and courses must be at least 14 hours (one credit course equivalent) per semester.*

Key words: *Education, ethics, undergraduate engineering curricula*

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Özet: *21. Yüzyılda bilim ve teknolojideki hızlı ilerlemeler, toplumda etik davranış ve ilişkiler hususunda bir farkındalık yaratmayı ve bir standart oluşturmayı gerektirmektedir ki, bu da ancak eğitimle mümkün olabilir. Bu eğitim olabildiğince erken bir aşamada verilmelidir. Aslında biraz geç olsa da, üniversitede etik eğitimi de bu amaç doğrultusunda, önemli bir aşama olarak ele alınabilir. Üniversite öğrencisinin değişik ve karmaşık etik problemleri ve ikilemleri anlama, analiz etme ve çözme yetisi oluşturulmalı ve geliştirilmelidir. Böylece, bütün meslekler le ilgili etik sorumluluk farkındalığının ve değişik meslek uygulamalarının toplumda ki etkilerinin ve etik problemlerinin muhtemel çözümlerinin anlaşılmasının etik eğitimi ile oluşturulması gerekmektedir. Üniversitede lisans programlarında etik eğitimi için düşünülen birçok metod içinden, birinci sınıftan başlayarak, programdaki farklı derslerde ele alınarak, programa entegre edilen ve son sınıfta ki temel bir derste "örnek vakalar" ile sonlandırılan metod, bu çalışmada önerilmektedir. Orta Doğu Teknik Üniversitesi Etik Eğitimi Komitesinin etik eğitimi üzerine yaptığı bir çalışmaya dayanarak, ders veya diğer uygulamaların süresinin lisans eğitim programı için en az 14 saat (bir kredilik ders eşdeğeri) olması önerilmektedir.*

Anahtar Kelimeler: *Eğitim, etik, mühendislik lisans eğitimi*

Introduction

In the last several decades, new critical technological developments faced many needs of society and have improved and continue to improve the welfare and the quality of life of every individual. The rate of the applications of these new inventions in different areas is very fast. However, the pace of social and moral considerations relating to these developments is not always fast enough. Knowledge and thus the

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increased power that is attained by the new technologies are accompanied by new problems that bring increased responsibilities to those who have the knowledge and to those who uses it. In all professions, professionals must have ethical awareness. As, twentieth-century philosophers claim, "the importance and effect of any mass depends not only to itself but also to the interaction of it with its surroundings and with its environment" (1). Therefore, the affect of any profession on society and surroundings and corresponding education must be discussed for future development of societies from an ethical point of view. Consequently, a new area for discussions is opened on how to build the ethical awareness among members of a society and especially among scientists and engineers who are responsible of the emerging technologies.

In the past three decades, there have been many efforts to include ethics in the curriculum of engineering and science programs all around the world. In USA, (2,3) the American Society for Engineering Education (ASEE), the Accreditation Board for Engineering and Technology (ABET) have gone over this issue and required "an understanding of professional and ethical responsibility" and "a broad education necessary to understand the impact of engineering solutions in a global and societal context." ABET in accrediting engineering programs asks for program outcomes and assessments (Criteria 3) 11 items that, "Engineering programs must demonstrate that their students attain." Among these 11 items, two is related with ethics as given below;

> "The ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturing and sustainability.
> The understanding of professional and ethical responsibilities."

In Europe, FEANI requires for the engineering schools to educate their students to full fill the statement, "…the engineer shall be conscious of nature, environment, safety and health and work for the benefits and welfare of mankind" which imbeds ethical concerns in each issue.

Engineering ethics, ethics education, professional ethics concepts had been studied by many engineers, philosophers and educators. Herkert (2002) describes the key concept in professional ethics as "professional responsibility" (4), while Whitbeck (1998) takes it as, "for someone to have a moral responsibility for some matter means that, the person must exercise judgment and care to achieve or maintain a desirable state of affairs (5)."

"Engineering ethics must address questions about ethical principles, rules of practice, justification, good judgment and decision making. It must also address questions about perception, imagination, including the underlying dispositions and skills of engineers"(6).

"Ethical responsibility" is defined by Winner (1990) as; It is "more than leading a decent, honest, truthful life. . . It involves something much more than making wise choices when such choices suddenly, unexpectedly present themselves. Our moral obligations must . . . include a willingness to engage others in the difficult work of defining the crucial choices that confront technological society (7)."

Martin and Schinzinger (1996) describe "the goal of responsible engineers" as "the creation of useful and safe technological products while respecting the autonomy of clients and the public, especially in matters of risk-taking (8)."

Inam (1993) defines the morality of engineers in relation to technological developments, and states that engineering is a new paradigm with the development of technology for the improvement of the welfare of

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human at the start, but later as a profession which is challenging the future of every living being (9). He suggests that the responsibility belongs to engineers.

Herkert (2000b) states that, "engineering ethics includes the ethical implications of public policy relevant to engineering, such as risk and product liability, sustainable development, health care, and information technologies (10)."

Lynch and Kline (2000) focus more on "culturally embedded engineering practice." They claim that, "knowledge of such nontechnical, but nonetheless ordinary engineering practice would provide engineers with the insight to anticipate safety problems before they escalate into technological disasters (11)."

Woodhouse (2001) states that "engineering ethics have traditionally overlooked macro ethical issues. He argues the problem of overconsumption which requires the immediate attention of engineers, and he suggests alternative approaches to engineering ethics based on 'collective professional responsibility' and the role of engineers as consumer-citizens (12)."

Ethics and ethics education (13-16)

The definition of ethics is done by many philosophers and can be found elsewhere. However, a practical one reflecting the dynamics in it, states that "Ethics, like the gyroscope, is a mechanism that must be used consciously and continuously to maintain direction, stability, and equilibrium" (17).

Ioanna Kuçuradi (2008) defines ethics only for the philosophical discipline as; "…which objectifies and sheds a strong light on the ethical human phenomenon as a whole, deals with and puts forth knowledge of ethical value and of ethical values- a knowledge which is a condition not only for the development and application of any code of morality and for the evaluation of the existing various morals, but also for acting in everyday life, in given real situations without giving damage to human dignity (18)."

Ethics as a concept is not static but dynamic and related with our actions. Philosophers, engineers and scientist are in consensus for its importance "to maintain direction, stability, and equilibrium" and also for the importance of its education. However, there are two debatable questions; 'can ethics be taught and how can ethics be taught?' Some articles and studies to answer these questions are summarized and given below.

Can ethics be taught?

N.S. Beheruz (2003) states that, "if the objective in teaching ethics at university is to create and develop value systems that will enable the person act ethically in his/her profession and inherent morality then, 'we are about 20 years late.' However, if the goal in this effort is to provide the student with a set of tools that could help him/her analyze difficult ethical situations, or provide theories, models, or approaches that might be useful in handling ethical dilemmas, or make him/her more sensitive to the ethical implications of some actions, or provide examples or case studies that might ring some bells later on in corporate life, then the objective can be met. (19)"

Ioanna Kuçuradi (2008) declares that, "one can be forced to act according to norms, but cannot be forced to act ethically...Thus, young people can be educated-and starting as early as possible-in value knowledge, and they can be trained in putting in connection this knowledge with the situations in which they have to act. This knowledge is what we need-and not the cultural norms--, if we-on our own account- have decided to live ethically. If we possess the will to live ethically, what we need first of all is ethical

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knowledge, ethical value knowledge (18)."

A.B.Carroll (2003) from University Georgia states that, "over 2000 years ago, the philosopher Socrates believed that, ethics consists of -knowing what we ought to do- and that this knowledge can be taught. Today many would agree with this statement. It is of course true that, ethics cannot be totally learned in the university classroom. But this is true for all subjects taught in classrooms (20)."

S. Johnson (1999) stated as, "Students often know the right thing to do." One of the students' statements is given as follows: "Certainly there are particularly difficult situations where we need the assistance… But ethics is not just about the hardest choices we will ever have to make; it is also about what we do all day every day. This brings up a simple observation about the moral life: Most of the time—really, nearly all of the time—we know what we ought to do. We're just having trouble doing it (21)."

This is interesting to notify because, recently, many philosophers give emphasis to "6th sense as, ethical sense". Ahmet İnam (2007, 2008)] a Turkish philosopher states as "...ethical awareness must be considered in each course, in the context and in the problems of each course, starting from the 1st year of the education. We can call this as insider ethics, digested in our knowledge and which is not at the outside (22,23)."

Tiatorio (1999) states as, "Human beings have an innate ethical sense that urges them to make predictable choices. Although most people believe that their actions are guided by logic and reason, reason often acts only as a mechanism to justify these choices." He continues as, "Ethics education is about recognizing the real power of one's innate ethical sense and how it influences ones behavior." He follows as, "ethical behavior is simply finding the balance between self-interest and group responsibility" and can be considered as, "learned behavior standing in opposition to an instinct. Acting ethically is very much like fighting an addiction… The history of ethical thought is, in this regard, a record of attempts to promote, or to dictate, communal behavior in order to ensure stability and harmony within the social group (17)."

Kohlberg (24) stated as, "Throughout the history consensus among many philosophers and educators was reached as that, the traits such as honesty, courage, perseverance, loyalty, caring, civic virtue, justice, respect and responsibility, and trustworthiness are not innate and can be attained through teaching and practice. However, ethics was innate and that there was indeed a moral sense." He continues such that, "Equality, reciprocity, even altruism, have been detected and recorded among animals, as well as treachery, deceit and manipulation. In fact, a kind of what goes around comes around golden rule is fundamental to the social relationships of most primate and that our biological heritage seems to predispose us to certain ethical standard." Crain argues that, "it seems more likely that, man is both driven by innate genetic forces and is capable of making thoughtful assessments of what is happening. Ethical thought is really no more than a rationale for an already cemented genetic ethical sense. The selfish individualism of our earliest and most independent past and the value of group life and finally of civilization itself are both deeply ingrained in us. These are the two natural sides of every human being, and finding the balance between them is basic to all ethical thinking. The evolved predisposition to act selfishly on the one hand and a selflessly on the other, while constantly seeking reasons to convince others of the rightness of our actions, is the ethical nature of man."

As a result of Tiatorio's, Crain's and Kuçuradi's proposals the questions to be answered are:

-How can we balance selfishness with selflessness?

-How can we face the pressure and affects of surroundings?

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-Is this possible by education?

-Is it possible to "provide the students with a set of tools that could help him/her analyze difficult ethical situations, or provide theories, models, or approaches that might be useful in handling ethical dilemmas, or make him/her more sensitive to the ethical implications of some actions, or provide examples or case studies that might ring some bells later on in corporate life" and

-By education can we help students to handle the trouble of acting ethically which is actually an innate?

These questions are tried to be answered using different educators and philosophers viewpoints.

How can ethics be taught?

This section is included because, many traits such as "honesty, courage, perseverance, loyalty, caring, civic virtue, justice, respect and responsibility, and trustworthiness" which are not innate and which are best described by Kohlberg (24) can only be achieved by moral development in education. It is believed that without moral development and ethics education, ethical behavior cannot be considered. Also, outcomes that must be attained by ethics education, methods, tools of education and different approaches for education and a case study carried out at METU are given below.

Education via moral development

Lawrence Kohlberg (25) "extended Piaget's work for moral development (understanding of moral concepts such as justice, rights, equality and human welfare). He identified six stages of moral reasoning within three major levels. Levels are indications of fundamental shifts in the social-moral perspective of an individual.

Kohlberg rejected the focus on values and virtues [25], not only due to the lack of consensus on what virtues are to be taught, but also because of the complex nature of practicing such virtues… Kohlberg believed a good approach to affect moral behavior should focus on stages of moral development which are critical; as they consider the way a person organizes their understanding of virtues, rules, and norms, and integrates these into a moral choice."

Kohlberg and his colleagues (25) developed the "just community" approach towards promoting moral development "by offering them the chance to participate in a democratic community. Here, democracy refers to more than simply casting a vote. It entails full participation of community members in arriving at consensual rather than majority rules decision-making. The group is small in size, aiming is to provide the students with a sense of belonging to a group which is responsive to individual needs. The central institution is a community meeting in which issues related to life and discipline in the community are discussed and democratically decided, with an equal value placed on the voices of students and teachers. An underlying goal of these meetings is to establish collective norms which express fairness for all members of the community. It is believed that by placing the responsibility of determining and enforcing rules on students, they will take prosaically behavior more seriously. At the same time, this approach stems from the cognitive-developmentalist view that discussion of moral dilemmas can stimulate moral development."

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Outcomes that must be attained by teaching ethics

Davis (1999) suggests that teaching ethics must achieve "four outcomes as

-Increased ethical sensitivity;

-Increased knowledge of relevant standards of conduct,

-Improved ethical judgment and

-Improved ethical will-power (that is, a greater ability to act ethically when one wants to" (26).

Yurtseven (2) agrees on the outcomes and discusses the outcomes from the point view of Program Criteria 3 for ABET Accreditation as "the understanding of professional and ethical responsibilities". Thus, if a program satisfies ABET Program Criteria 3, and then the graduates can be able to have the expected outcomes.

Methods and tools of education

Considering engineering ethics, many different models and attitudes have been advised (5,27-30), many books (8,31-35) were published. The main goal is to use appropriate models and techniques to teach the students some codes that they can use, in order to be able to make decisions about the ethical problems that they will face in the applications of technological developments which are unpredictable and to educate them in order "to develop the knowledge, skills, and attitudes to help society make wise choices concerning to the development and application of emerging technologies" (30).

Yurtseven (2) gives in his article current status of ethics teaching in engineering in USA where, in some universities education starts with moral theories, codes of ethics, case methods and in some others, it is integrated across the curriculum. Considering Herkert's (4) articles some methods and tools that can be used in ethics education are summarized and are given below:

Codes of Ethics: Traditionally, teaching ethics in different disciplines have included "codes of ethics and the application of moral theories." Unger (1994) is a "defender of the utility of codes of ethics, although, at the same time, he acknowledges their limitations (34)." Ladd (1980) argues that ethical codes "are largely self-serving and of little help when it comes to ethical reasoning (36)." Davis (1998) on the contrary, believes in the "usefulness of codes (37)."

Ethical Theories: Some philosophers declare the importance of ethical theories, stating that, "formal discussions of abstract moral theories are not necessary for teaching professional ethics and, indeed, might even be counterproductive because they may turn off practitioners who doubt their relevance."

Design Course: Whitbeck (1998) suggests that "the problem-solving approach used in engineering design can be a useful paradigm for solving ethical problems (5)."

The Case Method: As stated by Herkert (2002) "one of the most popular methods for teaching ethics is the case method", because it is easy to find cases in books, online or in videos. They can "encourage students to express ethical opinions; to identify ethical issues and to formulate and justify decisions; and to develop in students a sense of the practical context of ethics (4)."

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Herkert continues that several ethicists (38) "suggests also to use cases that focus on 'good works' that demonstrate sound ethical judgments which need not end with 'whistle-blowers' being expired from the firm, like the case of City Corp Building."

Curriculum Models-The Required-Course Model: Herkert (4) states that "this approach has been successful at Texas A&M (39). However, due to staffing costs and fixed packed engineering curriculum, the required-course model is not widely used globally. Similar to some other social science courses, engineering students can have an impression that ethics is an elective rather than an integral part of their engineering studies." On this respect, Unger (2005) claims that, "a special required-course on ethics can be aimed to focus precisely on engineering ethics or on the area of technology and society including engineering ethics in some lectures (40)". He describes further his course entitled "Technology and society" in which societal issues such as "energy, war, and privacy are considered together with professionalism and the handling of intra-organizational problems by some cases which illustrates ethical dilemmas faced by engineers." Relating to the location and the mechanism of "conducting a special course, his personnel recommendation is to be on the freshman year with case studies." He suggests that, "the course can be conducted through selected case studies that have engineering or social context, by two instructors (one engineer and the other somebody in the field of liberal arts or social science), where students in groups can discuss the cases freely before the instructor and their friends." He argues that, "through this procedure, students can have the chance to know their class mates at the start of the university education, will learn ethical code of conducts for the university and for the profession. They can learn the impact of technology on society, can advance their oral communication skills, can learn how to study in teams and can be more confident in their claims in a group."

Across-the-Curriculum Model: Another approach is to spread ethics education throughout the curriculum (2,13,41). Herkert (2002) states that, "across-the-curriculum approach necessitates the training and participation of faculty." Thus using this method ethics is placed in the mainstream of engineering education. The model success can be achieved by building a consensus among the engineering faculty for the importance of ethics instruction. The University of Michigan implemented this procedure by making some changes in their methods of teaching so that, ethics and safety can be seen as "common attributes of good engineering practice" (42).

At Illinois Institute of Technology (IIT), where they have an Ethics Center, M. Davis (26) has used a "pervasive methodology" and focused "on ethical issues in ordinary engineering problems without relying on formal moral theory and without sacrificing coverage of technical engineering material." They start by identifying an issue from code of ethics that underlines the meaning of "professional engineer" and then identify engineering problem that fits this issue in any course and then write a case on the problem. They claim that this procedure faces all the outcomes.

Integration of Engineering Ethics in Science, Technology and Society course: Herkert (4) recommends as "an ideal solution to use a combination of methods - a required course in engineering ethics and an engineering curriculum that recognizes the importance of ethics and addresses throughout: (i) professional and ethical responsibility and (ii) the societal context of engineering." He also gives a successful example of the model used at the University of Virginia School of Engineering and Applied Science.

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Different tools that can be used for ethics' awareness:

1.Prince (2006) emphasizes the "use of role-playing (active learning) as a teaching tool. York University experience is given by the two and three-part scripts for case studies based on NSF or original scenarios to illustrate issues such as gifts, attitudes towards women and ethnic minorities, conflict of interest, whistle-blowing, sexual harassment, individual rights, privacy, environment, intellectual property, and others (43)."

2.Fleischmann (2006) gives the role of honor code as: "honor code is certainly a good place to start teaching students about ethics, but teaching students to live honorably, requires far more effort than memorizing a code of ethics statement or applying it just to academic performance." Fleischmann also suggests that the cultural code is very important and must be taught in the context of an ethics course (44).

3.Tougaw & McCuddy (30) suggest that, recently, "case studies may not be an effective way to teach students about emerging technology", since the "new technology may be completely different than anything previously developed. A method to instill in the students principles that they can use to make decisions about previously unimagined technological developments is what is needed." Therefore, to implement ethics associated with emerging technology to undergraduate engineering students, "the human development metaphor" is recommended. In this approach, "understanding the history of society's technological developments and the increasingly complex and profound moral challenges that accompanied those developments can be achieved by building it directly on the students' own personal life experiences. The experiences of the students can be used to help them to recognize that, society has always assigned power and responsibility in equal measures. When one studies the development of an individual human being from infancy to adulthood, several key patterns can be observed. It is possible to use three of these developmental patterns to help students learn important lessons about the ethics of emerging technology."

"Increasing power is accompanied by increasing responsibility." Human development is accompanied by continually increasing control over one's environment. Thus, building an understanding of ethics of emerging technology leads to learn that, "technological advancements create

> -power over the physical and social environments and this power must be accompanied by the responsibility to use it wisely,
>
> -vast databases of highly confidential personal information, and this information is accompanied by the responsibility to protect it diligently,
>
> -obligations to focus on longer-term societal goals and to defer immediate gratification in the interests of achieving sustainability."

McCuddy & Tougaw (2007) in conclusion states that, …"interplay of technology and ethics…which are intertwined phenomena can be effectively explored in short training programs and can have profound implications for humanity. All the inhabitants of this planet are

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increasingly impacted by the moral consequences of emerging technologies. Having the capability to better understand and deal with those moral challenges will benefit everyone."

4. Unger (40) also stresses especially on "teaching professional responsibilities about major technology-society issues (energy, war, environment and privacy)." His suggestion to do this is by "occasional colloquium talks and special courses devoted to this general area". Some additional actions to take for teaching ethics are given by him as:

-"Distribution of engineering ethic codes, and posting them at places where students can see and read (in hallways, classrooms and laboratories),

-Posting short written essays on ethics related topics

-Organizing colloquiums and seminars for every semester,

-Encouraging the students related societies,

-Having orientation courses where engineering ethics are covered in 2 or 3 lectures,

-Including ethical issues in various technical topics,

-Devoting some lectures to important societal issues and inviting expertise people for some seminars on these issues,

-In all lectures devoting last lecture on survey of ethics in engineering,

-Simulation of real engineering ethics problems in a capstone design courses,

-Contributing to ethics education with the help of non-technical electives that are included in engineering curricula."

Study done on ethics education at METU (13-16)

Considering the ABET 2000 requirements and the need for a ethics education at Middle East Technical University, METU, a workshop study was carried in 2001 with the representative members of each department. The group is then divided to six sub groups making sure that each faculty is represented in the group. Then each group is given questions to discuss and asked to prepare a report on them. The results of this study are given below considering issues, tools, mechanisms and periods.

Topics: In order to create awareness for the students, the topics that must be covered in different courses or in similar activities are; ethics in university education, ethics in the life style of university, business ethics, work ethics, environmental ethics, research ethics, publication ethics, political ethics, media ethics, society life's' ethics and internet ethics.

Tools and methods: The procedures and tool that can be utilized in order to cover the topics given above are:

-For ethical awareness, another education program must be conducted for work-in education like the "Psychological Activities" given in seminars, workshops and in courses. These will affect the general conduct and will regulate the relationships between students and faculty,

-"METU Honor Code" must be established,

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-Consulting and Guiding mechanisms must be utilized which must also include the faculty.

-Each department must include ethics education in their curriculum. However, this must be conducted by integrating related topics in different courses. There must be some elective courses.

-Awareness must be given especially for "Plagiarism".

-In the book prepared by the Department of Basic English for beginners a chapter must be devoted to basic ethic concepts and values.

-In the four English courses throughout the curricula for undergraduate programs, at least two essays must be allocated for subjects concerning ethics.

-In "Conversation Club" that will be starting at "Self Access Center", seminars must be organized by experts.

-Academic Writing Center must inform faculty and students about plagiarism and about publication ethics.

-Seminars open to university must be organized by Research Center of Applied Ethics, RCAE.

Duration: Whatever procedure or mechanism is chosen, total allocated time is recommended to be either minimum 14 course hours (1 credit course equivalent) and maximum 28 course hours (2 credit course equivalent).

Conclusions

As a result of previous studies and the workshop done at METU it is clear that,

-Ethics education is essential for ethical awareness at the university in all faculties,

-This awareness education must include all the staff,

-Education can be done best, with integration throughout the curriculum in 4 years, starting from freshman.

-Subjects can be delivered either in

- a special course designed with case studies or,
- in different courses like; English language courses, introduction courses in freshman level, in social science elective courses in the junior and sophomore levels, project or product design courses and in independent seminar series in the senior class.

-Ethics education can be included also in other activities such as: orientation programs for beginners, Internet and University TV platforms with cases and discussions programs, advisory systems for students, Students Clubs, Academic Writing Centers, Conversation Clubs and 'Reading Books' of Modern Languages, seminars organized by the Ethics Center,

In the future, the engineering faculty must make sure that ethical problem solving skills, standards of conduct, and critical thinking skills are developed in the context of technical courses. Engineering faculty must consider the societal and ethical implications of engineering with self-education. Ethics education

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can only be complete, if the entire faculty are enthusiastic about and are willing to discuss ethical issues and the social and ethical implications of technology with their students.

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