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ENGINEERING IN THE COMMUNITY: CRITICAL CONSCIOUSNESS AND ENGINEERING EDUCATION

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ABSTRACT

The continually changing, contemporary global society has been placing new demands on the engineering profession. The complexity of today's environmental, social and economic context has prompted engineering educators to call for a general reform in engineering education. While the common theme among this professional group is the necessity of reforming the engineering curriculum, how this should be done, and which changes are needed, is still a matter of contention. Non-technical content in engineering curricula has been implemented in order to address the perceived lack in competences when it comes to social or "soft-skills". However, certain proponents of reform, e.g. S. Beder, E. Conlon and H. Zandvoort [1-3], have voiced concerns regarding the focus on "soft-skills" and management competencies on the one hand, and a certain disregard for a broader understanding of non-technical knowledge for engineers on the other. This broader understanding implies teaching engineering students to take into consideration the relevant social context and contributing to the community in their daily practice of engineering.

The first part of this paper deals with the mentioned contentions within the engineering professional community. As an answer to the described dilemmas, the paper explores the necessities and possibilities of incorporating critical thinking into the engineering curriculum. The paper proposes a tentative implementation of P. Freire's humanist education in engineering education [4]. The possibilities of the pedagogy of critical consciousness have the capacity to move beyond the mentioned divisions by merging practical social skills (i. e. "soft skills") with involvement in the community.

KEY WORDS

engineering education, engineering ethics, critical consciousness

CLASSIFICATION

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INTRODUCTION

Changes in engineering education have been happening since the Second World War and the general trajectories in the development of the engineering curriculum can be roughly divided into three periods. The engineering curriculum before the Second World War concentrated on the practical, technical activities in engineering education, without much focus on the theoretical emphasis in mathematics, physics and technical subjects. During the period between the 1950s and late 1980s (or the cold war era) there was a steady rise in the theoretical content in engineering education [5]. This development produced an imbalance within the curriculum, favoring theoretical knowledge in technical science and fundamentals (mathematics, physics) over practical technical skills and proficiencies. With the beginning of the 1990s, the inadequacies of the cold-war curriculum in a society transformed by fast-paced changes in technology were becoming more obvious [1, 6]. D. Goldberg, for example, described his experience with engineering students in the following way: "As a faculty advisor in Senior Design since 1990, I have learned how to coach students to successfully solve their problems, but I am continually reminded, year after year, about the mismatch between the education a cold war curriculum provides and the demands of a real-world engineering problems" [6]. Many interested engineering educators and professionals (S. Beder, H. Zandvoort, L. Bucciarelli, E. Conlon, etc), called for a reform towards a more rounded, holistic approach to the engineering curriculum. They emphasized the necessity of including more practical skills, as well as more non-technical, social content in engineering education.

This need for change has also been recognized in the wider engineering professional community. Many international organizations such as American Society for Engineering Education, IEAust., American Board of Engineering and Technology, SEFI, IGIP support a reform which would imply the balancing out between practical activities in the educational program and theoretical input for students, as well as the inclusion of non-technical content such as economics, psychology, management studies, sociology. The necessity of the proposed changes is emphasized in the following way: "The response lies in a new understanding of the role of science in innovation and the use of technology in context. This approach underlines the existing need to bridge the divide between the disciplinary knowledge of the technical sciences and social sciences, and the practical domains of engineering, with their unique knowledge and routines that integrate the social, practical, and technical aspects of technology at work" [7].

However, the way faculties are to proceed with the desired reforms is still a matter of contention. The first part of this paper deals with current contentions regarding contemporary dilemmas in engineering education, with a special focus on reform in the field of engineering ethics and social responsibility. The next section of the paper will try to provide the answer to the issues in engineering education and its role in promoting critical thinking and community involvement with respect to the philosophical thought of P. Freire. His critical pedagogy is especially suitable for engineering education because it is directed at positive change in the community. The last section of the paper aims to provide a basis for critical engineering education through suggestions for possible classroom exercises and changes in the teaching practice with respect to aspects of sustainability, social responsibility and ethical behaviour.

QUO VADIS ENGINEERING? – TRANSFORMATIONS IN ENGINEERING EDUCATION

The engineering profession has come to the realization that their future young colleagues will need a different type of education if they are to successfully tackle the emerging problems specific for this new and constantly changing era of technology and innovation. Work tasks of interdisciplinary nature require an engineer whose education has prepared them by teaching a broader set of themes than just scientific and technical fundamentals. The old paradigm of engineering education which promotes the belief that mechanical engineers deal primarily with issues of a purely technical nature [8], is slowly being replaced by new forms of education based on the idea of the so-called New Engineer [1]. Accreditation agencies have included requirements for the curriculum that emphasize the necessity of non-technical content [3]. In the US, ABET's accreditation criteria "require that engineering programs in the United States must demonstrate that their students receive 'the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context' and attain 'an understanding of professional and ethical responsibility' [3]. While substantial progress has been made when it comes to the consciousness of the necessity for changes in engineering curricula, many educational reformers believe that the practical value of these reforms is somewhat questionable.

S. Beder, H. Zandvoort, E. Conlon and L. Bucciarelli have all been discussing the salient problems in the way the mentioned recommendations for reform have been implemented [1-3, 9]. For example, theorist L. Bucciarelli [9] says that the directives issued by notable engineering association and accreditation agencies strike him as rather artificial. He criticizes the way the current engineering education teaches students about professional ethics and social responsibility. The teaching of ethical codes and acceptable ways of conduct through the study of artificial scenarios does little to prepare students for real-life situations. According to Bucciarelli [9], these exercises do not faithfully depict the "social nature of day-to-day engineering." The current practice of teaching engineering ethics is an oversimplified simulation of what might be encountered in a complex real-life situation. Engineers are constrained or enabled by the social, organizational and political relationships around them. "Ethics ought not be neglected in engineering education, but more fundamental and prerequisites for students to learn about the social, the organisational – even the political – complexities of practice" [9]. To deal with this problem, Bucciarelli proposes a thorough reform of engineering education programme so the students are able to grasp the social, political, environmental, as well as technical complexity of their professional activity. The working reality of the engineer is far too intricate to be encompassed by the study of cases in ethics or adding a non-technical subject or two, such as Science, technology and society [9]. Bucciarelli [9] believes that the curriculum should be structured in such a way so that the classic content of engineering education (mathematics and fundamentals) is infused with references to "authentic contexts".

S. Beder [1], one of the proponents of the New Engineer paradigm, suggests that positive change has been made when it comes to including non-technical content in engineering education. However, she parallels Bucciarelli's opinions that this added non-technical content missed its mark, so to speak. By mainly focusing on leadership and management skills, reforms neglect the issue of engineers needing to understand the broader social context of their professional activity. The changes which made room in the curricula for non-technical knowledge disregarded the need for developing a consciousness of the role engineering has in the community [1].

E. Conlon also discusses the incorporation of social responsibility in engineering education. Skills and knowledge pertaining to social responsibility became a requirement for a satisfactory engineering career and employability [2]. But Conlon also points out that the broader aspects of engineering ethics and social responsibility should be taken into consideration and implemented into the engineering curricula. Social structures that influence the possibilities of ethical conduct need to be taken into consideration. Conlon believes that social subjects such as sociology can help develop a broader, social perspective and consciousness among individuals for a better and more satisfactory practice of social responsibility. Conlon is advocating an awareness of "the importance of engineers being exposed in their education to criteria other than narrowly conceived productivity, efficiency and flexibility, and the importance of them understanding the wider social context of their work, including the regulatory environment, and how it enables or constrains the possibilities for designing meaningful work for others. A focus on the wider social context is also required if engineers are to contribute to creating a sustainable society" [2]. In a similar vein, Conlon and Zandvoort [10] reflect on the difference between micro and macroethics. Microethical approach in engineering education is focused on the individual engineer, his individual responsibilities towards society. This sort of teaching of ethics aims to prepare engineers for ethically challenging situations they might encounter at their places of work in various sorts of organizations. It usually focuses on theoretical studies of traditions in ethics and/or the study of real or imagined ethical dilemmas. Conlon and Zandvoort point out that this approach marginalizes the importance of social context and organizational and social limitations of a particular situation. Therefore they suggest the engineering curriculum should be enriched with macroethics which takes into consideration the whole situation circling the individual who has to deal with an ethical issue [10].

The prevalent situation of the non-technical aspect in engineering education is focusing on individual responsibility and individual cases. However, the direction of reform in engineering curricula should be aimed at responsible engineering for the betterment of the community and society. When Zandvoort described the ebbs and flows of engineering education for responsible and ethical behaviour he points out that despite "the agreement that there is a task for education to prepare its graduates for social responsibility, and despite ongoing discussion on the subject, there is very little clarity or agreement on what social responsibility entails, and what it implies for curricula to prepare graduates adequately for social responsibility" [3]. Furthermore, Zandvoort stresses the need to discuss and provide answers to questions such as: "What are essential elements in the preparation of engineers for socially responsible decision making and conduct? How should, and can, engineering curricula contribute to that preparation? What can be achieved within current curricular and other constraints? What further changes are needed in engineering education?" [3].

The prevailing doubts and questions posed by the mentioned eminent scholars suggest a further shifting of the paradigm of engineering education. This shift is characterized by "a growing dissatisfaction with individualist or personal professional ethics. Increasingly, the sense is that personal responsibility is necessary but not sufficient" [11]. In his paper "A historico-ethical perspective on engineering education: from use and convenience to policy engagement" C. Mitcham analyses the transformations in engineering education, and especially the shifting emphases in engineering ethics. He concludes that the current paradigm shift represents a move towards a "policy turn" or an emphasis on applied ethics. "There is an emerging (if still a minority) consensus in the professional engineering and the philosophical communities that personal ethics is not enough, that ethics – including professional ethics – must include analysis of and on occasion action to transform institutional arrangements and policy directives as they set contexts for the pursuit and

practice of engineering" [11]. Mitcham deliberates on the possible future of engineering with respect to the policy turn and the National Academy of Engineering report *The Engineer of 2020: Visions of Engineering for the New Century*, which states the necessity of educating "'engineers who are broadly educated, who see themselves as global citizens, who can be leaders in business and public service, and who are ethically grounded.' This would entail enhancing 'analytical skills, creativity, ingenuity, professionalism, and leadership" [11]. At the end of his article, Mitcham [11] discusses the possibility that the mentioned changes in engineering – the expansion of the curriculum to encompass liberal arts – point to a decline in social relevance of engineering and herald a period which he termed as post-engineering.

In response to the realistic objections formulated by the authors presented in this section, I believe that education in general, and engineering in particular, can benefit greatly from the thought and practice of P. Freire, a famous Brazilian pedagogue and philosopher. His critical pedagogy and its critical method are well suited to tackle with the emerging issues of education for social responsibility in engineering and active involvement of engineers for the betterment of the community.

ENGINEERING EDUCATION FOR CRITICAL THINKING

As a general concept, critical thinking can be described as the questioning of the system's status quo and re-evaluation of accepted truths. It is an important activity teachers should participate in with students on all levels of education. It is the appropriation of a critical stance, a questioning stance if you will, towards the social, political and economic system. Critical thinking is a means of liberating students, teachers, and transforming the educational system for a better democracy and society.

A major proponent of the critical thinking method in pedagogy was the famous Brazilian philosopher and pedagogue P. Freire. In his most famous book called *The Pedagogy of Oppression* [4], Freire described learning and the process of education as a tool for human liberation. In his view, critical thinking is (1) "thinking which discerns indivisible solidarity between people and the world and admits no dichotomy between them", (2) "thinking which perceives reality as process, as transformation, rather than as static entity", (3) "thinking which does not separate itself from action" [4].

With respect to the current debates and problems within engineering education and the criticism directed at the engineering educational reform which is having difficulties in producing productive action in the community, certain methods developed within the framework of Freire's critical pedagogy could be beneficial for the process of engineering education.

PAULO FREIRE'S CRITICAL PEDAGOGY

The social background of the Brazilian P. Freire was an important influence on his philosophy and work. Growing up in a poor neighborhood in Jaboatão dos Guararapes, Brasil, he was not particularly successful as a student. He believed that his initial poor results in school were a direct result of poverty. The main leitmotif in his reformist, or even revolutionary, vision of education is the influence of social class on the success of students in the educational system. As Macedo said in his introduction to Freire's book, Freire did not believe in the neoliberal utopias of a classless society and instead said "you cannot reduce everything to class, but class is an important factor in our understanding of oppression" [4].

During most of his career, Freire was working to promote adult literacy among the illiterate farmers of Brazil. During the course of his active career he developed his critical pedagogy. Freire thought intensively about the poverty and misery, not only of his countrymen, but of the misfortunate around the world, and could not help but wonder how to instill a sense of

criticism towards certain types of power in the community. The key to liberation, human liberation in general, lay in the formation of critical consciousness or conscientization in every individual human being. The possibilities of conscientization are connected to the hindering effects of formal education. The existing school system was something Freire was particularly critical of because he believed it worked for the political elite and the neoliberal economic system with the goal of hindering human liberation and progress.

The school system functions on premises deeply conflicted with the vision of a just society for free individuals. Firstly, the relationship between the teacher and the student is not based on the notion of equality. The teacher has more power to set the schedule and content of learning. Second, the participation of students is minimized. They are mostly expected to passively accept the preordained curriculum. Freire called this the "banking concept" of education [4, 12]. In formal education, both teacher and student are degraded and estranged from their social role as free human beings able to intervene and transform social reality. The teacher is reduced to a mere narrator of prescribed content which describes reality as "motionless, static, compartmentalized and predictable" [4]. The students are in turn reduced to containers or receptacles that passively listen to the narrated content. It was P. Freire's belief that this sort of education hinders creativity and critical thinking. Freire proposed an alternative to this educational setting. The alternative is called "problem-posing" education. Problem-posing education focuses on the resolution of the teacher-student contradiction and establishing dialogical relations between them. Both students and teachers are seen as partners in resolving pressing social problems. They are oriented at transforming the social context of a given limiting situation. "Education must begin with the solution of teacher-student contradiction, by reconciling the poles of contradiction so that both are simultaneously teachers and students" [4]. In problem-posing education, dialogue reserves special prominence. Teachers and students engage together in dialogue with their surroundings. The art of mutual communication, in place of mere transference of concepts into student-receptacles, transforms both the teachers and the students by changing their initial attitudes, and encouraging them to reflect critically on their knowledge, notions, and relationships. For Freire, the act of dialogue is an act of proclaimed equality. The banking system of education disables dialogue, critical thinking and actions directed at transforming reality. Dialogue, curiosity, creativity and critical consciousness actively seek to intervene and change society. This change should be enabled through the model of problem-posing education. For transformative intervention in society, the realization of social context is necessary. Freire proposes that this realization, or conscientization, be done through the use of what he calls "generative themes". Freire perceives the world and society as constantly changing and transforming as a result of people's reflection and intervention in society. Generative themes pertain to the characteristics of a certain society at a certain point of time in history. A rather general generative theme could be *domination*. The discovery and reflection on these themes implies their opposite possibilities. In the case of *domination* the opposite possibility is *liberation.* It is through the dialogue and discussion of generative themes that one reaches critical consciousness and at that point questions of change, action and transformation arise.

The mentioned theoretical concepts can be developed into educational tools in the contemporary formal educational setting. Although Freire developed his critical educational method with relation to illiterate adult farmers of Brazil, who had limited access to communal decision making, his insights are particularly valuable and are used as instruments of educational change in various educational contexts throughout the world [13]. His methods can be implemented into engineering education with respect to teaching methods that directly influence the engineer's ability to question the assumption of a society which is in many

respects unjust and unsustainable. Not only should engineering students develop a healthy critical consciousness, they should also become more actively involved in transforming communities towards a more egalitarian and sustainable future.

Critical Method and Sustainability

The discourse of sustainable development has already found its place in education in general, and in engineering education in particular: "The focus is on engineering, more than on natural and physical sciences or on social science, because the activities that drive the industrial state – the activities that implement scientific advance – are generally rooted in engineering" [14]. The demands of sustainable development are often criticized as being guidelines which social actors are not obligated to abide by or participate in. This usually results in the perpetuation of the unsustainable situation present in today's global society. The goal of education for sustainable development is to prepare students to contribute to sustainability individually. However, as was previously mentioned, engineering education focusing on individual responsibility does not contribute substantially to the transformation of the whole community towards sustainability. The first step towards positive change should be the formation of a critical consciousness directed towards the social context that inhibits sustainability. To develop critical consciousness, engineering students and their teachers should participate in the critical method aimed at discovering Freire's "generative themes". The process of discovering generative themes is part of the teaching method of critical pedagogy. This method is comprised of four phases. In the first phase students and teachers engage in discovering various themes by a "careful study of students' everyday lives" [13]. This is called reflecting upon "situationality" [4], the social context. After this stage, a "codification session" with students is enacted whereby students draw pictures of the discovered themes. In phase three, students are encouraged to examine these images and perceive them as problems to be solved. Initially, the problems are discussed as problems of individuals, but are later turned into "collective problems with underlying reasons" [13]. The codification then leads to the formation of generative themes and reality is discovered to be under human control and subjected to change. In the final stage students start to plan the creation of conditions for solving the discovered problems and transforming the current social context.

One possible product of this exercise could be defining generative themes such as poverty, capitalism, or finally, sustainability itself. If poverty were to be defined as one generative theme, students would use the method of dialogue to discover the causes and consequences of poverty on an individual and collective level. The opposition to poverty is prosperity; so the problem to solve would be bringing sustainable prosperity to people with insufficient means for material subsistence. One way of solving the problem could be by what M. Pavlova calls "design projects for low-cost products" that would produce affordable items or simple production processes for members of the developing world. These projects could be included within classes in engineering, and they "involve students in the process of formulating tasks, undertaking research and development and evaluation of ideas, their presentation and realization" [15].

Critical Method and Social Responsibility

One aspect of the project for sustainability is social responsibility. Within engineering education it is mostly "understood as involving a commitment to a socially just, equitable and sustainable world" [2]. With respect to issues within the discourse of social responsibility, engineers need to take into consideration a variety of themes such as, for example, employees rights within companies and organizations. Engineers should be aware of workers' rights and help workers attain these rights. To be able to do this, the engineer needs to have good

communication skills, teamwork skills and a highly developed empathy for potential problems his subordinates, co-workers or colleagues might experience. One of the class exercises leaning on the premises of Freire's pedagogy of the oppressed would be the implementation of A. Boal's theatre of the oppressed in the classroom setting. Methods used in Boal's theatre can be a useful tool for learning to establish channels of communication, resolving conflict situations, becoming aware of the other's point of view, and transforming the perceived injustices of social reality [16]. The basic method or branch in theatre of the oppressed is called the "Forum theatre". The Forum theatre is staged so that there is no real division between the actors (performers) and the audience. The audience or, in Boal's terms, spect-actors, is allowed to intervene into the play at any time in order to influence or change the outcomes of a scene. The performers can take on various roles, such as oppressor/antagonist, the oppressed person, the ally, or the invisible witness. The scene played in a classroom could be about a boss who mistreats an employee. Spect-actors can stop the scene, exchange roles, become the oppressed or the oppressor and can suggest courses of action, solutions to the situation, or forms of changing the relationships within an organization.

The enactment of this sort in often used in educational settings to promote a unique sort of dialogue among the participants and to prepare people for situations in real life; for cases when they often do not know how to react and what to do in a specific constellation of social or organizational relationships. Sullivan and Parras [16] point to the following benefits of the mentioned methods in education: "Ally / spect-actors also have the opportunity to rehearse networking skills, to practice risk communication with their neighbors, and to question central assumptions of prevailing power dynamic: these activities are all sources of personal empowerment for the actors, for spect-actors, and even merely witnessing these scenes unfold empowers other members of the audience to do likewise, in the world beyond the Forum."

Critical Method and Engineering Ethics

The impetus for placing more emphasis on introducing engineering ethics in the engineering curriculum, whether in the form of separate courses or as parts of existing subjects, came from the realization that engineers often face ethical dilemmas at the workplace [17, 18]. The confusion between prerogatives of the capitalist system, the loyalty towards the company, organization and clients on the one hand, and the local community, the general population, or the environment on the other, requires critical reflection as well as the ability to empathize, communicate and transform through active involvement. Mere studying of ethical codes for engineering, and theoretical knowledge in ethics will hardly prompt students to take an active role in the community. Heikkero [19] points out that "an ample toolkit of *skills* is also necessary: without engineer's having the ability to notice social and moral issues, reason about them, combine the reasoning with scientific knowledge and engineering praxis, and then communicate, these social responsibilities will exist only on paper." He believes that students need to be motivated on an emotional, affective level to be willing to act. In other words, they need to learn how to recognize unethical behaviour, and they need to want to change what they see.

A classroom exercise that would be useful for encouraging students to take an active stance and create change could be a variant of Freire's critical method in combination with role playing similar to Bola's theatre of the oppressed. The students can choose a situation or an event that is potentially harmful for the environment like building a nuclear power plant, or a thermal power plant. They can take photographs of an environmental problem happening in their own neighborhood or a place they know. After a brief discussion about who the potential actors in the scene might be (farmers, people living in the local community, politicians, entrepreneurs, reporters, employers, engineers, etc.) the students than take on

different roles and stage the different perspectives in the scene. Students can even play out the negative effects of some kind of pollution on the local community such as various health problems. During and after role playing, students, together with the teacher can discuss the various aspects of the situation and their emotional responses. Through this exercise of becoming conscious of problems and other's point of view they can define courses of action that would correspond to the principles of applied ethics. Some students might actually apply these solutions for pressing problems in their own place of residence, their local community.

CONCLUDING REMARKS

The engineering education is transforming to encompass a broader set of themes because our common future mandates a struggle for sustainability, environmental protection and eradication of poverty and inequality. The reforms conducted until now have not produced the desired far- reaching results. The reforms implemented until now were oriented towards the purpose of making the curriculum attractive to potential students, and making it easier for students to get jobs with a broader set of skills which include many different social skills. However, pressing concerns for developing ethical engineering for a sustainable and viable future are still at issue. Therefore, engineering educators have called for deeper changes in the curriculum or even its complete reorganization in order to include applied policy practices and to encourage future engineers to actively participate in changes for ethically and environmentally responsible behaviour. Whether or not the expansion of the curriculum and the inclusion of different non-technical subjects not traditionally belonging to the domain of engineering somehow show that engineering as such is losing its prominence in society is a matter of speculation on possible future trajectories of the global society. The importance of science and innovation in the context of the proclaimed coming of "knowledge society" makes ethics and social responsibility important. If the current curricula and educational reforms do not produce the desired results, then it is our duty to question their very foundations and to suggest possible changes. One such suggestion is presented in this paper and it pertains to the incorporation of the teaching methods of P. Freire into the daily practice of teaching at engineering education institutions. The described exercises are done in a constricting setting of formal education, often artificially simulating real-life situations, and where the hierarchy between students and educators/teachers is still very much present. Freire nonetheless offers important lessons on where to start if we aim to change our social surrounding for the betterment of our planet and our society.

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INŽENJERSTVO U ZAJEDNICI: KRITIČKA SVIJEST I OBRAZOVANJE INŽENJERA

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SAŽETAK

Suvremeno globalno društvo, koje se neprestano mijenja, postavlja nove zahtjeve profesiji inženjera. Složenost današnjeg okolišnog, društvenog i ekonomskog konteksta potaknulo je nastavnike inženjerstva da pokušaju pokrenuti opće promjene u inženjerskom obrazovanju. Iako je pitanje nužnosti reforme inženjerskog obrazovanja postalo uobičajena tema, oko same reforme i načina njezine provedbe postoje mnoga neslaganja. U inženjerske je kurikulume uveden netehnički sadržaj kako bi se kompenzirao primijećeni nedostatak kompetencija na području društvenih ili "mekih vještina". Međutim, određeni zagovaratelji reformi, primjerice S. Beder, E. Conlon i H. Zandvoort [1-3], izražavaju zabrinutost kada je u pitanju usredotočenost reformi na "meke vještine" i menadžerske kompetencije s jedne strane, te određeno zanemarivanje šireg razumijevanja netehničkog znanja inženjera s druge strane. To šire razumijevanje netehničkog sadržaja podrazumijeva podučavanje studenata da uzimaju u obzir relevantni društveni kontekst i da pridonose zajednici kroz svoju dnevnu inženjersku djelatnost.

Prvi dio rada bavi se već spomenutim različitim razmišljanjima unutar inženjerske profesionalne zajednice. Kao odgovor na opisane dileme, članak istražuje potrebe i mogućnosti uključivanja kritičkog razmišljanja u inženjerski kurikulum. U članku se predlaže pokušaj uvođenja humanističkog obrazovanja P. Freirea u inženjersko obrazovanje [4]. Kritička pedagogija ima potencijal nadići spomenute razlike u pristupu inženjerskom obrazovanju spajajući praktične društvene vještine (tj. "meke vještine") s općim doprinosom zajednici.

KLJUČNE RIJEČI

inženjersko obrazovanje, inženjerska etika, kritička svijest