Collectively and Critically Reflecting on Technology and Society
A Cooperative Approach to Engineering Ethics

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INTRODUCTION

Engineers can no longer develop new technologies just for the sake of technological progress, while environmentalists try to conserve nature. They have to become aware of their interdependency and work together to lay a groundwork for a common engineering ethics and its implementation. This counts equally for the social dimension where philosophers and social scientists take up the role of environmentalists.

The purpose of this paper is to highlight the need of an entirely different approach to the education of engineers. The Blue Engineering course at the Technische Universität Berlin (TUB) promotes socially and ecologically responsible engineering based on democratic decision-making. Furthermore it encourages participants to work cooperatively in order to induce social change through collective action.

1 GENESIS OF BLUE ENGINEERING

The Blue Engineering-Project was started off by a group of four students during the winter-semester of 2008/2009 at the TUB. It was meant to be not only to a single course but as a whole network to support engineers to reflect on technology and society and act accordingly. They worked out their idea a little bit further, sketching a common basis to bring students and working engineers together in order to teach

and learn from each other and take their social and ecological responsibilities seriously. Blue Engineering is meant to provide an appropriate framework for engineers to reflect on technical achievements in general and one's own personal responsibility in particular.

However, from the beginning Blue Engineering was not intended as a mere theoretical discussion, but was also about exploring and expanding one's liberties at university and work. Their goal was to gradually change the whole concept of engineering one step at a time. Their idea was picked up by fellow students and together they were determined to put it into practice.

This group formulated few central but not final principles aimed at providing a common understanding of ecological and social responsibility as the theoretical basis for Blue Engineering. The consensus-driven process of finding and agreeing on the common ground was solely based on general knowledge and common sense of everyone participating. Under these principles the development and use of technology involve the gentle and sustainable use of earth's finite resources, e.g. the reduction and prevention of toxic substances and transportation. Technologies should be developed according to the specific needs of their users and be locally adapted to the environment and society. They need to be durable, repairable and recyclable. Socially responsible engineering means respecting the rights and opportunities of all people. At the workplace this includes good working conditions, participation, freedom of association and reflecting and acting in teams (even across organisational borders). Accordingly, the resources of the planet we all share must be distributed evenly.

2 COOPERATIVE APPROACH TO ENGINEERING ETHICS

Apart from these guiding principles sketched at the very beginning, the Blue Engineering group has identified in a consensus-driven decision-making a theoretical basis. At its core is the concept of society-nature relationships and radical democracy in order to integrate the micro/macro dimension as well as the subjective/objective dimension. Consequently, Blue Engineering is based on a a cooperative approach to engineering ethics.

2.1 Integrating the micro/macro and subjective/objective dimensions

Up until the recent past most of the teaching of engineering ethics was all about exploring the role of the individual engineer in ethical dilemmas through case-studies. The growing dissatisfaction with the limits of this approach eventually lead to the development and implementation of newer concepts. Eddie Conlon analyses these new approaches with the help of the theoretical framework provided by the American sociologist George Ritzer [1]. This sociological analysis is done in two dimensions: microscopic/macroscopic and subjective/objective. The first continuum refers to all social phenomena along an axis starting with an individual action (micro) up until whole societies (macro). Along the second continuum a distinction of social phenomena is made ranging from a real material existence (e.g. technology and bureaucracy) to mere ideas and knowledge (e.g. culture, norms and values). Crossing these two dimensions results in four quadrants with each one representing a specific paradigm [2]. The fruitful changes in the teaching of engineering ethics notwithstanding reside according to Conlon mostly within one quadrant alone which means that they are based only on one single paradigm. Consequently, the cost of overcoming the limits of the micro subjective paradigm is the loss of its advantages, e.g. the strengthening of ethical willpower.

Rather than focusing on one single paradigm Conlon follows Ritzer and calls for an

integrated approach which needs to take the dialectical relationship between the four paradigms into account. “It can be suggested that an integrated approach would incorporate the four levels of analysis into the consideration of any ethical problem and examine both the values and commitments of engineers but also their capacity to act on these values and commitments.” (p. 157) The *micro subjective paradigm* adds to this integrated approach the individual engineer and her/his capacity to identify and solve ethical dilemmas, while the *macro subjective paradigm* covers the goals and values of engineering in general. The organisational setting in which engineers work is considered through the *micro objective paradigm*. The fourth paradigm deals with the social, economic and political structures. Through this *macro objective paradigm* it becomes possible to address the power issue and approaches to change society as a whole. This integrated approach sketched by Conlon is not based on a narrow understanding of ethics, instead he calls for a multidisciplinary strategy which covers philosophy, sociology, politics, history and law (p. 158).

2.2 Society-nature relationships

The Blue Engineering Project is based on the belief that social as well as ecological dimensions have to be taken into account in respect to promote responsible engineering. It is committed to a cooperative approach to adequately address the interdependency of engineers, environmentalists, philosophers and social scientists in the course of constructing, developing, producing and using technology. The concept of *society-nature relationships* (Gesellschaftliche Naturverhältnisse) [3] [4] [5] provides the theoretical background to overcome the strict separation between natural, technical and social sciences as it points to the reciprocal linkages between society and nature.

The idea of technological innovation as a warrant for a prosperous life and as panacea for multiple crises is a phenomena deeply rooted in our mental infrastructures [6]. This perception can be traced back to the bourgeois project of enlightenment. Adorno and Horkheimer [7] identified the concept of the “domination of nature” as one of the enlightenment’s central characteristics and dilemmas. At its core lies the total subordination of nature by technical means in order to serve societal purposes [3].

The concept of *society-nature relationships* refers to the individuals and society as not determined by nature. As nature is socially produced to a certain extent, it can also not be produced at will. Jahn and Wehling [8] indicate that society and nature are rather to be understood as “differently distinguishable and internally differentiated poles of a dynamic, processual relation of mediation” (p. 82). Conceptualizing this relationship as dialectic helps to illustrate their constitutive co-dependency [5]. Brand and Wissen [9] argue: “Society-nature relationships are concrete material relationships structured by social processes of production and consumption and defined by social perceptions and interpretations, which, in turn, impose certain limits on these constructions” (p. 4f.).

In order to create conditions under which the appropriation of nature does not take on the form of the domination of nature and people, every single person has to learn to be responsible for all issues concerning society and its relationships with nature. These include, amongst others, decisions about basic needs, technologies, distribution, investment and modes of production and consumption as well as about the social division and organization of labour [10]. However, people can only be expected to live up to their responsibilities, if they can individually participate in the respective decision-making processes.

2.3 Radical Democratization

Blue Engineering attaches great importance to radical democratic principles like consensus-driven decision-making, a very high level of participation, equal rights for everyone participating and a minimum level of hierarchy in order to enable people to act according to their values.

As more and more technological innovations turn from solving problems into creating them, it gets apparent that nobody may avoid the effects of technology [11]. Therefore technology concerns all of us and consequently every single one must have the opportunity to participate in the respective decision-making. This participation can only be organized and carried out within collective community-based democratic and bottom-up structures. The democratization-process should be aiming towards a way of life that ensures equality amongst individuals and across societies.

Basically this call for a radical democratization-process implies that territorial impact of decisions needs to be taken in consideration. Everyone who has to deal with the ensuing consequences must have a voice in it, even if they are living far away from the place of implementation. They must have the chance to participate and to negotiate about what is necessary and what is considered sustainable and sufficient. On the other hand, attention has to be equally paid to the impact of decisions over time as we create path dependencies through the installation of technological infrastructure and certain harmful side-effects may only show up centuries later.

Decisions involving great uncertainty, where and if reversibility is not an option, have to be at disposal [10]. If the introduction of new technologies are at stake, possible dangerous unintended side-effects and dependencies must be carefully considered. Consequently, only those decisions that can be revised can claim legitimacy.

Nevertheless we should not be too enthusiastic about the rationality of democratic decision-making, but overall participative, bottom-up democracy is the only safeguard so far for the prevention of the most destructive patterns of the appropriation of nature with its according negative socio-ecological impacts [10].

3 THE BLUE ENGINEERING COURSE

The educational concept was developed over time in a consensus-driven process. It is based entirely on the general knowledge and the common sense of the participating members of the Blue Engineering group. Instead of relying on a fixed concept beforehand, they first asked themselves how they want to learn in university. Only at a second step they asked themselves what specific content they want to learn which goes along with their principles [12]. As the Blue Engineering course is still under constant development, the following part will not be a thorough theoretical analysis, but it will be rather a first sketch of the concept and a description instead.

For the first four years Blue Engineering was a fully student-driven project. Therefore, they did not design the course from a teacher's point of view. As students they developed a course concept which is not primarily about teaching but mainly about facilitating. The learning outcome depends more on the students as individuals and as a group. Consequently, the Blue Engineering course is not at all teacher-centred, but uses a wide variety of teaching methods. Accordingly and with the intention to create equal rights this led to the common understanding that the course in general has to be designed with just a minimum level of hierarchy. The ones facilitating the course are asked not to regard themselves as lecturers but rather as peers who actively participate in peer-to-peer learning. This might even lead to participants taking over responsibility and conducting parts of the course themselves. Therefore,

the people responsible for the course do not function as experts who lecture but rather as moderators of group- and learning-processes. They facilitate a common critical reflection on technology and society through a set of didactical methods. Finally they encourage the participants not to work alone but to cooperate with others in order to change things through collective action.

3.1 Building-Blocks

The core of this concept are self-contained study-elements - named building-blocks. The underlying design principal of these building-blocks is that they provide an appropriate set of didactical methods to enable any generally interested group with a maximum of 25 persons to acquire a certain insight into the ecological and social dimension of technology. Most of them address during a 90 minute session a complex issue, e.g. ethical codes, «technology as panacea», technological large-scale projects, technology and gender, social businesses and cooperatives. Every single block has to be designed and documented in a way that any layperson or expert is able to prepare a building-block within just a few hours and to conduct it for a given group, e.g. working engineers within a company for their continued education. All of the 30 so far developed and tested building-blocks consist of a well documented, easy-to-use manual that provides all relevant information about the specific content, respective sources, external partners, clear didactical instructions along with a timetable. Several building-blocks are already freely available through the Blue Engineering website. It is planned for the future to make the documentation of all existing building-blocks publicly available in an open access database with the option to comment, review and improve them.

A short description of two building-blocks may help to better grasp the whole idea: One 90 minute building-block is based on the article "Das produktivistische Weltbild" (The Productivist World-View) [11] which had a very important influence on the general development of Blue Engineering. Small groups of participants work themselves through the whole article, which is structured into three chapters. All groups have to present three times certain parts of one of the chapters. All of the presentations have a different form, ranging from mind-mapping, storyboards to role-playing. After each presentation the small groups moderate a short discussion along a key question. A general discussion structured through a little quiz finishes the block.

There is one building-block which covers the organisational structure of companies, also addressing pressure at work/burn-out and workers-rights/labour unions. The principal method here is to encourage participants to use and train their skills in creatively solving problems. This is done in order to empower single engineers to use their capacities to induce change at their workplace. Additionally, the participants have the chance to present, discuss and solve problems they have identified at their work as prospective engineers, e.g. during internships.

There are other building-blocks which use classical case-studies, simulation games, democratic decision-making, trials, creativity and arts, controversial discussions, and so on to discover the interdependency of nature, technology, (wo)men and society. In total the building-blocks combine many different methods and didactical concepts so that participants not only learn content but strengthen various competences through the continued, diversified interaction in groups ranging from two to 25.

3.2 Course-Design at the Technische Universität Berlin

The Blue Engineering group at the TUB initially developed, tested and documented a set of 13 building-blocks. The Blue Engineering-Course was designed to offer a three hours class over the 15 weeks of a whole semester. Additionally, the participants are

requested to work in groups on a project which will be incorporated into the further development of the course or into the work of Blue Engineering. This sums up to six ECTS-points or a total of 180 hours of workload per semester. Although it is a course at the faculty of mechanical engineering and transport systems, all other students, even from other departments and universities are equally welcome to join the course. Even working engineers are invited to participate as part of their continued education.

A single session usually starts with a 90-minute building-block. Just a few building-blocks actually integrate all four identified paradigms of engineering ethics, but most of them combine at least two paradigms [2]. Over the course of one semester the participants will thoroughly discover all four paradigms along with their strengths and limitations. During the first weeks of the semester the building-blocks will be conducted by the ones responsible. This is done in order to give the participants a good understanding of how building-blocks work in general. Eventually, small groups of participants are asked to take responsibility and conduct a building-block to their fellow students. Several times over the course of a semester experts linked to the topic of the building-blocks are invited to the course in order to give an insight into the real-life problems inside and outside of academia. These include working engineers and different actors from civil society, labour unions, companies and politics.

During the second half of the three-hour course the participants are supported in developing their own building-blocks or pursue similar projects. They work in groups of two to four and are free to choose any topic as long as it is related to socially and ecologically responsible engineering. They are also free to choose their didactical method and to determine the outcome of their project on their own as long as it is reusable or recyclable in future courses or in the work of Blue Engineering. Consequently, mere presentations, term papers and similar forms will not be accepted. Preferred are for instance newly constructed or refurbished building-blocks, radio plays, exhibitions, card-/boardgames, encyclopedic treasure chests, e-learning-units, etc. If possible, they are requested to do their research not only through surfing on the internet and reading but are encouraged to interview people, do experiments, field research and the like instead. Although most of the work on these projects will necessarily be done outside of class they will also receive assistance in class. For instance, the participants are supported to choose their topic, giving them a variety of didactical methods at hand and holding several sessions of peer-to-peer feedback. Furthermore, a high quality and an overall critical examination of the chosen topic is ensured through continuous mentoring by the responsible persons of the course and former participants.

Around the 12th Week of a semester, a whole study day is used to test all created building-blocks in real-life conditions. All other projects will also be presented in respective manners. To increase the student’s motivation for their work they are encouraged to invite family members and friends.

During the remaining three weeks the students are assisted and given peer-to-peer feedback to write down the documentation of these newly created building-blocks and other projects. Over time this led to a collection from initially 13 to now 30 building-blocks and a big variety of realized projects which are used regularly, e.g. small exhibitions.

3.3 Implementation of the Course at the Technische Universität Berlin

Blue Engineering is associated with the research chair for machinery system design at the TUB. Thanks to the help of Prof. Dr. Henning Meyer funding was received to employ four students of the Blue Engineering group as tutors. These four tutors were then solely responsible for conducting the premier of the Blue Engineering course

with 25 participants ranging from their first to their last semester and coming from five of seven faculties at the TUB. The course was credited with six ECTS points despite its experimental stage in winter-semester 2011/2012. The official evaluation ranked this course in all but one aspect better then the faculty's average. Only the suitability of the course-room was ranked below the faculties average as the room was too small for the extensive group work. Additionally, several rounds of feedback were held in order to ensure a continued improvement of the course. Overall the participants supported the variety of teaching methods and the mix of topics. Most of them were surprised that three hours can pass by so quickly. However, some asked for more thorough discussions and a better grounding in scientific facts and findings.

The next Blue Engineering course was offered in the following summer-semester 2012. The course design was just mildly adopted according to the feedback. Three of four tutors had to quit working due to their own studies and the high additional workload through the course. However, the course for 25 students was equally successful which proofed that it was not depending on one particular person or expert to be conducted. The course feedback was quite similar to the preceding semester. Most of the participants wish for more courses in their curricula which offer alternative teaching methods and the critical examination of technology and society. However, participants asked for good practice examples to get a concrete idea on how to implement their critical examination. Overall the students gave the feedback that they are highly motivated for the course because they are asked to create something meaningful which will be reused.

With the start of the winter-semester 2012/2013 at TUB a two-year project was launched with two lecturers and two tutors associated with the chair of Prof. Dr. Henning Meyer. They are fully integrated into the Blue Engineering group and its activities, but focus mainly on the further establishment of the course at the TUB. Their goal is to gradually adapt the course-design so that eventually four classes of 25 participants per semester may be reached. The challenge here is to guarantee the overall course-design, while requiring only a minimum of additional faculty personal once the project is terminated. Alongside that, an intensive qualitative and quantitative evaluation will be conducted.

CONCLUSION

The development of Blue Engineering from a mere idea of a small group in winter-semester 2009/2010 to two parallel courses with 25 participants each in summer-semester 2013 shows the potential which students have to strengthen ecological and social responsibility within engineering. Universities just have to facilitate space and time to let them decide how and what they want to learn. Most likely they will choose the topic which is the least represented in the teaching of all the fact-based knowledge of engineering: Ethics. Their approach will probably not be a narrow one as it is practised in philosophy but rather it will be an integrated approach covering not only the various sciences but also the various actors of our pluralistic society.

However, Blue Engineering is much more than merely raising the awareness of (prospective) engineers through one single course. Participants are encouraged to stay in touch, to network within their organisations and beyond their organisational borders. They may even found their own Blue Engineering groups at work or in universities, as it has already happened at Technische Universität Hamburg and at Nordakademie. Both offer their proper courses since winter-semester 2012/2013. They are based on different designs adapted to the local circumstances, but the overall concept remains the same.

Over the course of time Blue Engineering might become a framework for the collective action of (prospective) engineers to strengthen socially and ecologically responsible engineering. Thus, it is a fully integrated and cooperative approach to engineering ethics which is not restricted to academia alone but which will gradually integrate all areas where engineering is done, notably within companies.

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