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Gunter Bombaerts [1]
TU Eindhoven 0000-0002-8006-1617.
Eindhoven, the Netherlands

Karolina Doulougeri
TU Eindhoven, Eindhoven, the Netherlands

Nienke Nieveen
Twente University, Enschede, the Netherlands

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ABSTRACT

Ethics education is part of many engineering curricula and at the same time a debated matter in terms of its goals, extent and educational approach. The quality of ethics education is, however, not prominently described in engineering education research (EER). To answer this gap, we perform a literature review that focuses on ethics education in EER. We analysed the data using a general quality framework that considers four elements of quality, i.e. relevance, consistency, practicality and effectiveness. We find that EER elaborates on the relevance of ethics education in three different ways: realisation of conceptual goals as honesty, integrity, or social responsibility; support of engineering concepts as complexity or risk; or instrumentally to comply with national educational standards. EER has little focus on consistency, except for the link with the entire curriculum. Also practicality is little developed, only on whether assessment is valid and reliable in ethics education. Teachers' perceptions of the instrumentality (is it helpful in teaching), congruence (does it fit the circumstances) and cost (is it feasible with the available time and resources) are less stressed. Debates on effectiveness in turn are prominent in ethics education and focus on the influence of: student characteristics and competences; course design; connection with the curriculum; and broader cultural aspects. We conclude that consistency and practicality are largely missing in ethics education in EER and that many implicit notions of relevance and effectiveness exist. This framework can make quality more explicit and impact the discussions on ethics education in EER.

[1] Corresponding Author: Gunter Bombaerts, g.bombaerts@tue.nl

1 INTRODUCTION

Few people would argue the importance of high quality engineering education and therefore the concept of "quality" has been discussed extensively in many places around the world. In literature on the concept of quality, two main perspectives can be found. The first emphasizes that engineering education should reach high standards of student outcomes. Within this line accreditation criteria have been developed and used, such as the Engineering Criteria 2000 (EC2000) by the Accreditation Board of Engineering and Technology (ABET) and ISO 9000 international standards. Both highlight learning outcomes and assessment and consider factors that concern the mutual recognition and global mobility of the engineering profession [1], [2]. A second line emphasizes meeting standards for the planning and acting of engineering education. This line considers factors that affect the quality of engineering education process, such as the importance of specifying clear educational goals and matching the educational and assessment methods adopted to these goals. Moreover, this line also considers the actual teaching processes of engineering education [3].

In this contribution, we introduce an evaluation framework that goes beyond both perspectives. The framework compares student outcomes with course intentions and the way the teaching and learning processes are being implemented. Moreover, the framework takes into account the expectations regarding course intentions, implementation and outcomes of different stakeholder groups, i.e. university-based curriculum (policy) makers, university teachers and students. Combining these responses and observations provides a rich basis for course (re)design and improvement.

We use this model for an exploratory literature research in which we do not aim to be exhaustive, yet want to sketch a first view how quality in ethics education in EER is currently described, what are the possible blind spots or specific emphases.

2 THEORETICAL FRAMEWORK FOR QUALITY

2.1 Course representations

Quality in ethics programs is rarely dealt with in a systematic way. Ocone [4] introduces a checklist as a practical tool for looking at ethics leadership (asking heads of department, course teachers and industry), visible ethics (effects on students) and actual ethics behaviour (observations in meetings). To interpret, understand and communicate about course-related issues, such as ethics course improvement matters, the curriculum typology by John Goodlad [3], is a valuable model to extend Ocone's approach. This typology distinguishes different representations of a course or curriculum: the intended, implemented and attained curriculum. First of all, a course can be described or represented by its *intentions*. Course designers, as well as other stakeholders will have their ideals when thinking about the aims of the course and what the course should look like. During the design process, course designers will make these ideals tangible by writing up the plans in a course guide and its accompanying teaching and learning materials. These formal documents usually do not (and cannot) cover all original ideals. Moreover, typically several redesign cycles are needed up until all course materials are ready to use. Next to its intentions, a course can also be represented by the way it is *implemented* in the teaching process by teachers/lecturers and others involved. Teachers may (and usually do) deviate in their perceptions of the original teaching and learning materials. They do this based on the characteristics of the students' group, previous teaching experiences and contextual factors. These perceptions will also affect the actual teaching and learning processes, the operational curriculum. For instance, teachers add illustrative examples, questions, dilemmas, etc. in order to assist students in their understanding and application of the topics at hand. Finally, the course can also be represented by the *attainment* of students. Based on their backgrounds, earlier experiences and interests, students, but also others involved, usually differ in the way they experienced the course and deviate in their performance outcomes.

2.2 Course quality

For clear communication about a course, the three representations and six forms (as summarized in *Table 1*) is of support. The same typology has also proven to be an aid in understanding relationships and discrepancies between the different representations of the course in practice. In this section, the typology is used to illuminate the notion of course quality [5], [6] and linked to four quality criteria: relevance, consistency, practicality and effectiveness. According to the logic of the framework, a high quality course should suffice for all of four quality criteria.

Table 1. Overview of curriculum representation and form with explanation and quality criteria.

Representation	Form	Explanation	Quality Criteria
Intended	Ideal	Vision (rationale or basic philosophy underlying a curriculum)	Relevance Consistency
	Formal	Intentions as specified in curriculum documents and/or materials	
Implemented	Perceived	Curriculum as interpreted by its users (especially teachers)	Practicality
	Operational	Actual process of teaching and learning (also: curriculum-in-action)	
Attained	Experiential	Learning experiences as perceived by learners	Effectiveness
	Learned	Resulting learning outcomes of learners	

2.3 Relevance

As far as a good quality course in concerned, the course itself (the intended course/curriculum) must be well considered. All course elements (such as its goals, content, assessment strategies) should be based on state-of-the art knowledge and considered relevant to the course objectives. Largely this is comparable to the content validity of a course, referring to the question to what extend do experts agree on the essential parts of the course elements? Expert opinions of course can differ. For ethics courses, the distribution of what is relevant is large. Different experts and stakeholders might disagree on what the relevance for ethics (education) is to realize the universities mission and vision or for the future profession of engineering students.

2.4 Consistency

The course design itself should show consistency. This quality aspect bears a resemblance to construct validity and to the notion of constructive alignment [7]. Constructive alignment emphasises the need of clear linkages among the intended learning outcomes, the assessment tasks and the learning environment (teaching and learning activities) that students are required to engage in in order to reach the intended learning outcomes. In this contribution we refer to the need of coherence between all components of the course and the entire curriculum [8], including its rationale, the aims and objectives, content, learner activities, teacher role, materials and resources, grouping, location, time and assessment. Every subject has its own specifications and own interlinkages. For students and for many other teachers, the specifications of ethics education are sometimes difficult to understand.

2.5 Practicality

Already more than 40 years ago Doyle and Ponder [9] pointed at teachers' ability to make on-the-spot judgments about the practicality of a change proposal. The practicality that stems from this (and has been elaborated for instance by Janssen, Westbroek, Doyle and Van Driel, 2013) [10] refers to teachers' perceptions of the instrumentality (is it helpful in teaching), congruence (does it fit the circumstances) and cost (is it feasible with the available time and resources) of the proposal. Translating this into the framework at hand, this means that teachers should consider the proposed courses to be usable for their teaching practices. In our framework, we would add that teachers, tutors and assistants not only expect the context elements (materials, rooms, group sizes …) to be supportive but that this should also be their perception after actually having taught the courses. Practical courses show consistency between the intended and perceived curriculum and also between the intended and operational curriculum.

2.6 Effectiveness

Finally, the outcome of the course is important. Students’ experience (the experiential curriculum) are usually measured in student satisfaction surveys, in some instances extended with focus group interviews to gain more in-depth data on their perceptions [10] And of course, high quality courses also show desired learning takes place and students pass the course by reaching its learning objectives. With effective courses, similarities exist between the intended and experiential curriculum and the intended and attained curriculum.

3 RELEVANCE CRITERION IN ETHICS COURSES

We see three subfields discussing relevance of ethics courses, which is a focus on conceptual goals, more topics related approaches and approaches that focus on complying with national educational standards.

3.1 Conceptual goals

Conceptual approaches in ethics education quality discussions aim for a cluster of interrelated concepts. Iona & Ursu [11] state values as the relevance of the ethics part in the curriculum: "The importance of introducing ethics in the technical education syllabus is undeniable, taking into consideration the fact that engineers are expected to reach the highest standards of honesty and integrity, especially because their actions have a vital, direct impact upon the quality of life!" Conway [12] enlarges this to "Teaching and learning strategies are needed that highlight the social and environmental context of technological activity, that encourage pupils to consider what determines the quality of their own lives and those of others, and that stimulates reflection on the values and beliefs which influence the priorities when value judgements are being made." Bielefeldt and Canney [13] focus on social responsibility (SR) attitudes, Bekkers and Bombaerts [14] on 'the role of the engineer of the future' and Johnston and Eager [15] on social significance of engineering: "Recognition of the social significance of engineering education and engineering practice needs to be reflected in a much broader and more integrated approach to the construction of engineering programs generally, and to issues of professional practice and ethics in particular." Feister, Zoltowski, Buzzanell, Zhu, and Oakes [16] analyse the reflexive characteristics of "how students interpret and make sense of their work in an engineering education context, and how this context may impact students' development and understanding of ethical decision making". Finelli etal. [17] and Carpenter et al. [18] enlarge this concept to ethical development as a combination of knowledge of ethics, ethical reasoning, and ethical behavior. Other authors focus on professional responsibility [17], ethos of modern engineers as "lifestyle and professional identity" [19] and perspective-taking, moral efficacy, moral courage, and moral meaningfulness [20]. Lastly, some authors discuss the narrow focus of ethical systems discussed and the lack of universities openness to other ethical systems. Murrugara [19] for example shows that Chilean universities with existing ethics courses teach them using a philosophical or theological perspective, limited to occidental theories, and usually from a Christian point of view, not focussing on indigenous viewpoints. Verrax [21] points at three failures of common ethics education in France, i.e. ordinary versus disaster ethics, involving the public, and taking into account power relations.

3.2 Topics related approaches

A second set of publications frames the relevance of ethics in engineering education in more concrete and engineering related aims and concepts as professional codes [22] (Hess and Fore indicating that this is the most common ethics education approach in engineering programs in their study [23]), complexity, context and sustainability [24], risk [25], global perspective [26] or macro-ethical perspectives [27]. Also critical professional skills are considered important for the relevance of ethics education such as the students' technical oral and written communication, professional and working relations between team members, project and time management [28], adaptive expertise [29] or soft-skills [30].

3.3 Complying with national educational standards

A third set of articles defines relevance of ethics courses by their need to comply with national educational standards. Barry and Ohland [31] discuss accreditation requirements for the Accreditation Board for Engineering and Technology (ABET), the Computer Science Accreditation Board (CSAB) Engineering Criteria 2000 in the USA and course accreditation requirements of engineering education in Australia. Rowden and Striebig [32] propose a three hour unit on the economic and environmental impacts of product design is proposed for inclusion in the ABET accredited engineering program. Passow and Passow [33] propose to broaden "ethics" in the Washington Accord or ABET accreditation requirements to “responsibility”.

4 CONSISTENCY CRITERION IN ETHICS COURSES

Ethics education quality discussions focus far less on consistency and is never explicitly mentioned. If the issues is discussed, it is often in the debate about embedding or separate ethics courses. Even here, the focus is more on practicality or effectiveness. Another way consistency enters the quality debate is by the practice-what-you-preach principle. Farahani and Farahani [34] for example write about all staff’s task to show respect for the students’ safety and health, privacy, and showing trust, respect, tolerance and openness.

5 PRACTICALITY CRITERION IN ETHICS COURSES

Thirdly, practicality in ethics in engineering education mainly focusses on whether assessment is valid and reliable. As Goldin, Pinkus and Ashley [35] state it: “Assessment in ethics education faces a challenge. From the perspectives of teachers, students, and third-party evaluators like the Accreditation Board for Engineering and Technology and the National Institutes of Health, assessment of student performance is essential. Because of the complexity of ethical case analysis, however, it is difficult to formulate assessment criteria, and to recognize when students fulfil them.” Several instruments have been developed to answer this challenge: Student Engineering Ethical Development (SEED) survey [18] [22] [17] (Harding 2015 SEED-PA …), moral reasoning skills survey [35], Engineering Professional Responsibility Assessment (EPRA) [13][36], Schwartz value profile [37], and the Engineering and Science Issues

Test (ESIT), measuring “moral judgment in a manner similar to the Defining Issues Test, second edition, but is built around technical dilemmas in science and engineering”. [38]

Whereas these methods focus on the ethics part alone, other methods analyse the entire engineering competence development. The Academic Competence Quality Assurance framework [39] for example, measures all engineering competences, including “takes account of the temporal and social context”. All these approach consider the context-specific needs of different engineering disciplines in ethics education and leverages the collaboration of engineering professors, practicing engineers, engineering graduate students, ethics scholars, and instructional design experts. ([40] to add to the practicality of the ethics education in EER.

6 EFFECTIVENESS CRITERION IN ETHICS COURSES

We group our findings on effectiveness in student and course, curriculum and ‘university and beyond’.

6.1 Student and course

Johnston and Eager [15] state that “effective treatment of social and ethical issues should not be trivialized by superficial approaches to analysis and presentation. We […] suggest some practical ways in which both breadth and depth can be achieved, and to highlight problems we see as needing further attention.” Ooi and Tan defined effectiveness in an ethics workshop as “student’s theoretical understanding on engineering ethics and student’s perceptions on ethical/non-ethical behaviour through case studies.” [41] Bielefelt and Canney [13] found that change in social responsibility attitudes occurred more in courses treating themes as international, community, ethics, service learning projects, and development. Others refer to multidisciplinary project teams as core to work increase ethical decision making [16] or Schwartz value profile [37]. Alfred & Chung [42] report on the effectiveness of a “Simulator for Engineering Ethics Education” placing students “in first person perspective scenarios involving different types of ethical situations. Students gather data, assess the situation, and make decisions. The approach requires students to develop their own ability to identify and respond to ethical engineering situations. It is based on a mathematical model of the actual experiences of engineers involved in ethical situations.” Other research focusses on learning outcomes of the ethics education as intrinsic motivation [43] [], deep learning [44],

6.2 Curriculum

The curriculum is also seen as an important level for the effectiveness of ethics courses. Bielefeldt etal. [45] found that “only 30% felt that undergraduate students in their program received sufficient education on both the societal impacts of technology and ethical issues; only 20% felt this way about their graduate program.” May and Luth [20] found that “both embedded and stand-alone courses were effective in enhancing participants' perspective-taking, moral efficacy, and moral courage. Moral meaningfulness was marginally enhanced for the embedded module condition. Moral judgment and knowledge of responsible conduct of research practices were not influenced by either ethics education condition. Contrary to expectations, stand-alone courses were not superior to embedded modules in influencing the positive psychological outcomes investigated." Drake *etal.* [46] advice engineering ethics to be "integrative, delivered at multiple points in the curriculum, and incorporate specific discipline context" to increase students' moral reasoning and sensitivity to ethical issues. Literature focuses also on co-curricular experiences next to formal curricular experiences [17] and volunteer activities to increase societal responsibility [13]. Lin therefore advices engineering programs to "incorporate more explicit instruction about the social dimensions of engineering to support the development of socially responsible engineers." Findings suggest that the number and type of co-curricular experiences have an important influence on ethical development. [18] [47] for example state that "industrial training has minimal impact in improving or developing students' ethical awareness. The impact is such because students who undergone industrial training may have observed certain behaviour that they thought are acceptable in a workplace; this may have changed the way students perceived their acceptance on the situations." Barry & Ohland [31] state that "more courses or course time on professionalism and ethics will necessarily lead to positive engineering education outcomes. Much of the impetus to add more curriculum content results from a lack of conclusive feedback during ABET accreditation visits."

6.3 External university

Effectiveness is also determined "beyond" the curriculum. Carpenter *etal.* [18] found that the institutional culture made a difference on how students behaved and how they articulated concepts of ethics. [19] found that "research work into the processes of forming the professional ethos of today's generation of engineers, its complexity and challenges of its reform involves the creation of a public image of the engineering profession as a certain subjective picture of the world, the tracking of its structural and content dynamics in the course of professional training, as well as a study of the professional academic community and the transformation of its mission and strategy."

7 CONLUSION

7.1 Discussion

Using our quality framework based on John Goodlad, our exploratory search shows that consistency and practicality are largely missing in ethics education in EER and that many implicit notions of relevance and effectiveness exist. Although relevance receive strong focus, it is often implicitly mentioned, it is unclear if the statements are the opinion of the individual scholar, a formal statement of the result or a clearly lived-by norm within the university organisation. We tend to believe that most principles mentioned in the literature are individual and still heavily debated within universities. Consistency is absent in the debate on ethics courses' quality and little is written on practicality. The articles refer little to teachers' perceptions of the instrumentality (is it helpful in teaching), congruence (does it fit the circumstances) and cost (is it feasible with the available time and resources) of the proposal. Nevertheless, the practical application and therefore final quality, heavily rely on consistency and practicality. Many questions remain here. How can the consistency between courses contribute to ethics education quality? How does the practicality of measuring outcomes in ethics courses influence the education itself (multiple choice questions, difficulty to measure attitudes …)? Debates on effectiveness are again prominent in ethics in engineering education. However, also here, many questions remain. What about the effectiveness of the ethics education in light of student diversity (first year's vs last years, gender, ethnicity, religious backgrounds …)? How do engineers and companies see effectiveness of ethics education?

We showed that this framework made quality more explicit and impact the discussions on ethics education in EER. Further research should reveal how the criteria relevance, consistency, practicality and effectiveness can be better addressed to keep adding to the overall quality improvement of ethics education in EER.

7.2 Limitations

We are aware that we opened up a large debate in which a lot has to be said, far more than one single article. Our analysis therefore does not show our exhaustive research results, but aims only to be explorative and sparking off the ethics education quality debate. This means that for the relevance and effectiveness criteria, we know there is more in the literature. We did not focus on the role of companies in the ethics education quality debate. There is a debate on corporate social responsibility, but what does it imply for the companies role in ethics education in engineering curricula? We of course also acknowledge that we might miss parts of the literature. It might be possible that other concepts in ethics education in engineering curricula can show us wrong in that consistency is absent.

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