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Document status and date:
Published: 06/12/2021

Document Version:
Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:

• A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
• The final author version and the galley proof are versions of the publication after peer review.
• The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

CHALLENGE-BASED LEARNING TO IMPROVE THE QUALITY OF ENGINEERING ETHICS EDUCATION

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Conference Key Areas: Ethics, Maffioli Award
Keywords: Challenge-Based Learning, Engineering Ethics Education, Quality, Redesign

ABSTRACT

The SEFI 2021 annual conference committee provided me the opportunity to publish this text based on the SEFI Francesco Maffioli Award. I am happy to use this opportunity to sketch the Engineering Ethics Education (EEE) and Challenge-Based Learning (CBL) research I have been doing the last seven years. I will focus here on the redesign of a large first-year's course for ethics and history of technology as an example. I will conclude with expressing my confidence that the dynamic communities working on for CBL and EEE can tackle the future challenges I list here.

1   INTRODUCTION

The SEFI 2021 annual conference committee provided me the opportunity to publish this text based on the SEFI Francesco Maffioli Award "in recognition of open-minded development of curriculum, learning environments or tools, novel didactics, methods or systems in engineering studies." I am happy to use this opportunity to sketch the Engineering Ethics Education (EEE) and Challenge-Based Learning (CBL) research I have been doing the last seven years, together with so many enthusiastic and dedicated teachers and researchers, in which the core of my work has been to contribute to the quality of EEE at my university (Eindhoven University of Technology).

I allow myself a more narrative writing style in this text, telling the story of the previous seven years of course- and curriculum redesign and attempts to better understand what was happening and which improvements could be useful using evidence informed approaches.

2   CONTEXT: AMBITIOUS USER-SOCIETY-ENTERPRISE PROGRAM

I started at TU/e in 2014 as coordinator of the Eindhoven "USE" program. This program aims to increase students' awareness, knowledge and attitudes of the links between User-Society-Enterprise aspects of technological innovation [1]. It is a Bachelor College program that shows the ambition of TU Eindhoven on ethics and societal aspects in engineering education. First year's students have a 5 ECTS mandatory course on ethics and history of technology (the "USE basic course"). In their second or third year, students have a "USE course sequence". This is a 15 ECTS course in which students focus on a specialisation of a technology, linked to a human science discipline, like "robotics and ethics" or "standards and patents in mobility" or "psychology and smart lightning applications" (see [2] for more information). The course offers content and methodology of the human science discipline, together with a concrete application of the technical and social science knowledge in an actual case.

This interdisciplinary approach is ambitious. The student evaluations, based on the questions "Are you satisfied with this course?" and "How would you rate this course?", have been mixed. Some USE course sequences score high, comparable with high scores of the own major courses, other USE course sequences score lower (see for example [3]).

As an ethics researcher, I really like to link insights in my own research, as community energy [4], participation and risk perception in innovation [5]–[8], nuclear waste governance [6], [9], [10] or intercultural ethics [11]–[13], to the future societal role the role of experts in society [14], [15]. It is probably particular to social scientist in Engineering Education that they can relate their disciplinary work to the reflection of the future societal role of the engineering.

As coordinator of these USE courses, I had the pleasure to find out with many motivated colleagues how we could improve these courses. First, this question is challenging as the quality of ethics and social sciences courses in engineering curricula is far from evident. Together with colleagues, we used the Goodlad curriculum model to apply it to social sciences and ethics courses [16]. We started with the attained curriculum, looking at motivation and deep learning, and slowly also moved to the implemented and the intended curriculum. For brevity reasons, I mainly focus on the redesign of the USE basic course.

3   OUR JOURNEY

3.1 Redesign

We redesigned the course in an evidence-informed way doing action research [17]. As the course evaluations in 2014 showed that students' motivation for the course

was low, we analysed motivational issues using self-determination theory in 2016. As reported in EJEE [18], we found that students in the 2016 USE basic course did not dislike ethics per se, but found the assignment not challenging enough, leading to lower intrinsic motivation and this in turn to a lower overall evaluation and feeling of relevance.

The USE-basic team (among others Antony Meijers, Andreas Spahn, Frank Veraert and Karolina Doulougeri) invited Jan van den Akker to do a rigorous redesign using the spider web in 2017-2018. We came up with an overall redesign of the course, but also decided to go for a challenge-based learning experiment for a group of 180 students in 2019-2020 (with Shelly Tsui and Mandi Astola). "In CBL, learning starts from an open ended, real life challenge and students are given the freedom to think out of the box and design a project directed entirely by them […] involving real-life opened challenges in collaboration with external industry partner." [19] Students in the CBL ethics course developed technical solutions for real-life ethical challenges. The student groups produced a diverse range of end-products. For example, CASA, one of the external stakeholders, presented the challenge "How can CASA use sensors in smart houses such that it respects privacy and ensures security?" Concluding that the CASA house did not pose any ethical issues if its occupants were well-informed, one group developed Fourier transformations to change the sensor data into data that is not meaningful for future inhabitants but could still be used for acoustics analysis, thus avoiding privacy issues. A two-minutes video can be found here, Figure 1 shows some pictures.
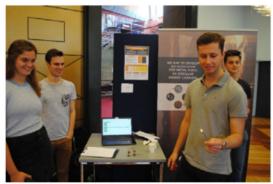
Figure 1: Pictures of the Challenge-Based Learning Ethics course 2019

Students raised that the ethics CBL course nudges them to do technical developments, but they do not receive formative and summative feedback on these technical aspects. As such, the "E3 Challenge2" course (E3 stands for Eindhoven Engineering Education) was designed as a 10 ECTS course, still dealing with 5 ECTS of ethics of technology, but broadened with 5 ECTS of data analytics (involving many TU/e colleagues and teachers as Adam Watkins, Jeff White, Rick de Lange, Regina Luttge and nine dedicated teaching assistants)

The experiment aimed at: (1) maximising self- and shared-regulated learning; (2) maximising ethics learning in a complex context; (3) upscaling CBL with teaching assistants; and (4) learning about teacher and teaching-assistant support in CBL projects. The course comprised different learning activities in a weekly cycle. (1) Students participated in ethics-centred learning activities. (2) A trio of teaching assistants (background in ethics, data, and the case) organized student peer-feedback. (3) Expert meetings in which experts are present (teachers, sometimes also external stakeholders) scaffold the overall project work. (4) Each team weekly met with their coach for 30 minutes and students individually wrote a weekly reflection answering three questions: (i) "Describe a learning experience from this week."; (ii) "Why was this learning experience important for you?"; and (iii) "How will your learning be different next week based on this experience?". There was a weekly peer-to-peer meeting with the TAs to support their work and a weekly meeting with the teachers to evaluate the previous week and plan the next week.

3.2 Results and impact

We used an evidence-informed approach analysing many aspects of the course, like feedback, structure versus open-ended challenges, motivation and context (see for example[16], [20]–[25]). In a recently published article, we compared the 2019 challenge-based learning version with a non-challenge-based learning version. The

results on students' motivation and basic needs showed positive results. Teachers in the course were satisfied about students' learning, but the quantitative analysis using the ACQA-competencies framework could not confirm that [26].

4 IMPORTANT CHALLENGES FOR A DYNAMIC COMMUNITY

I hope I made clear that the SEFI Francesco Maffioli Award for me is in the first place a recognition of the work of two vibrant communities, one on Engineering Ethics Education and one on challenge-based learning. I could say: "I was just lucky to be, enthusiastic and dedicated, in the middle". I would therefore like to use this last section to acknowledge some people and sketching the work that I think is in front of us.

A first important motor for EEE is certainly the SEFI Ethics Special Interest Group with Roland Tormey, Diana Martin and many other committed members organising monthly online sessions, openly exchanging results, ideas, and feedback, and being very active in organising workshops and writing research output. For those interested, here you can find updated info (and subscribe to the newsletter 😊). The Ethics SIG can only be this active because many people across Europe are engaged. I had the pleasure to work in the SCALINGS consortium studying co-creation in general and the link with CBL in particular in numerous captivating peer-to-peer session with TUM Germany, DTU Denmark, UEW Poland, ESADE Spain, University of Troyes France, Imperial College London UK. Several of these partners are now continuing the work in an Erasmus+ project EuroTeQBoost supporting CBL in Tallin University Estonia, TU Prague Czech Republic, TUM, DTU, EPFL, I'X Paris France, and Technion Israel. I also am pleased with the collaboration with Christian Herzog in a fellowship Hochschullehre 2020.

Of course, there is also my institute, Eindhoven University of Technology, that strongly supported my colleagues and me. Getting support from the management (the deans of the Bachelor College Ines Lopez and Graduate School Paul Koenraad and my Philosophy and Ethics group chair Wybo Houkes) who allowed me to spend time and money to all these experiments. A special thanks to Andreas Spahn with whom I have been redesigning a lot of the USE basic course and all the other teachers and students I worked with and with whom we together optimized the CBL courses.

Getting the prize is an acknowledgement, but this does not mean that the journey is over. Many challenges (yes, researchers also have challenges) of CBL are ahead of us. With Karolina Doulougeri, Michael Bots and Jan Vermunt we will look into the intriguing question "how students learn in CBL" [19]. With Diana Martin, Tijn Borghuis

and other colleagues we will analyse the interplay of EEE and CBL, like "How can moral competencies be measures (with ACQA)?", "How can interdisciplinarity in cases of CBL be optimised?" [24], [25] and "What is the influence of engineering students' views on knowledge (epistemic cognition) on how they learn in CBL?". With Lukas Fuchs and Isabelle Reymen, we will approach CBL from a university-ecosystem angle, studying the interaction between CBL in a university's curriculum on the one hand and the responsible attitudes of organisations in the ecosystem (university, companies, communities, NGO's) on the other hand.

This is for sure a fantastic trip. I want to make one critical and realistic note here. My university too is an organisation with different opinions and dynamics that go different ways. Whereas the last years, the compass was really on educational innovation, currently this is more in debate. A new Bachelor reform is being discussed in which ethics and social sciences get far less attention. I certainly see the idea of colleagues being enthusiastic about *their* courses and wanting to increase them (I of course want the same level, or more, ethics). However, my personal worry currently is that this transition might go hand in hand with a lean and non-innovative education that allows teacher-researchers to do as much research as possible. I sincerely hope, and am confident, that my university keeps holding its educational innovation high in esteem.

I hope to meet you all, *in flesh and bone*, at SEFI 2022 to exchange more educational innovation stories.

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