

First-year engineering students' experiences with a course of ethics and history of technology

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First-Year Engineering Students' Experiences with a Course of Ethics and History of Technology

Dr. Gunter Bombaerts

Gunter Bombaerts is Assistant Professor for Philosophy and Ethics of Technology at Eindhoven University of Technology, the Netherlands. His research fields include ethics in engineering education (motivation, deep learning, competence measurement), comparative ethics and questions concerning applied ethics in the field of energy ethics, in particular on participation and innovation. He is coordinating the TU/e USE program and is teacher of USE courses (amongst which the USE basic course on History and Ethics of Technology).

Dr. Karolina Doulougeri, Eindhoven University of Technology

Dr. Karolina Doulougeri is a post-doctoral research fellow in the Technological University of Eindhoven. Her research focuses on engineering students' motivation and deep learning strategies, coaching in design based learning and educational redesign of engineering courses. She received her PhD in Organizational Psychology from the University of Macedonia, in Greece. She has worked in several international research projects focusing on students and employees' well-being, professional development and performance. Her work has been published in peer reviewed journals and presented in several international conferences.

Addressing different needs of first year engineering students in a course of Ethics and History of Technology

Research Paper

Abstract

Previous analyses of an 11-week course on ethics and history of technology, taught to 2000+ first-year engineering students showed low motivation for and satisfaction with this course of students in Informatics and Applied Mathematics (INF/AM) and in BioMedical Technology (BMT). In our inquiry, we started from the following research questions: “Which aspects of the USE Basic course do students of INF/AM and BMT consider interesting and challenging? What are the differences in the 2018 version in students’ deep learning and motivation with the course compared to 2017 after the implemented changes?” We combined three fields for the background of our research: deep learning, learning environment and self-determination theory. We used a mixed-method approach focusing on the two target groups INF/AM and BMT. We performed qualitative focus group discussion, a test run before the course and observations. Validated quantitative questionnaires on deep learning, learning environment and motivation were electronically taken. T-tests were used to compare results with the previous year.

Qualitative results showed that BMT students consider themselves as mere cog-wheels and not responsible and that many words in their courses (as ‘project’, ‘feedback’ ...) mean completely different things in the courses of the own department. Students of INF and TW showed a different profile. TW students were quite aware of what was happening in the world at the moment, INF were far less. Both wanted clarity (even ‘baby-steps’ in their own words), but INF students needed much more linearity, for example in study guides and explanations of assignments. INF students in our sample acknowledged to have difficulties reading things. The quantitative results of the differences between the 2017 and 2018 for the history and the ethics part for the INF/TW and the BMT showed a mix pattern and will be discussed.

The conclusions indicated that the apparent disinterest of INF/TW and BMT students goes far deeper than a uselessness of ethics and history for first-year engineers. It pointed at their way of looking at reality and at their own professional identity. It pointed at the difficulties of general courses to offer educational methods that were interpreted differently from student groups of different departments. And it pointed at differences at basic competences needed to dive into deep learning and to be motivated by what is offered by the course. Solutions are discussed.

Introduction

Future engineers are not only expected to have technical knowledge, skills, and abilities, but also a foundation in professional and ethical practices [1]. One important challenge for educators is that students show large differences in how they perceive courses and what their educational needs are [2]. In this article we focus on a large first year engineering students course in history and ethics of technology since it magnifies the student differences and the challenges it entails. The course focuses on User-, Society- and Entrepreneurial (USE) aspects in technological innovations and exposes engineering students to current dilemmas related to technology. [3]

Despite efforts for redesigning the course, yearly evaluations indicated low student satisfaction [4]. The same groups of students remained unsatisfied. Students majoring in Biomedical Technology (BMT), Applied Mathematics (AM) and Informatics (INF) evaluated the course significantly lower (4.18 on a 1-10 Likert scale) compared to the rest of the students (6.13). Given that this is a large group comprising yearly roughly 30% of the student population, it was decided to conduct a qualitative study in addition to the overall survey evaluation to understand better the specific learning needs of these particular students, in order to be able to design better the course and address their expectations and needs. From a course redesign perspective, one has to take into account the particularities of specific students, redesign the course for all students and “hope” that the redesign for one group will also benefit the other groups.

Theoretical Background

Potential differences in specific learning needs can be described by approaches of learning that are distinguished in surface, strategic and deep approaches to learning [2, 5–7]. Students with a surface approach have a main objective to pass the course and they make use of strategies such as rote learning, memorizing or repeating the learning content. Students with a deep approach are intrinsically interested in the course and they try to comprehend the meaning of what they study. They try to relate new information to prior knowledge to structure ideas into meaningful constructs. A strategic approach in learning has also been described and refers to students who mostly focus on effective organization of the study material and time management as a way to succeed in the course [8].

The factors affecting students’ approaches to learning have been the topic of extensive research suggesting an interplay between students’ personal characteristics, characteristics of the teachers and the characteristics of the learning environment [9]. Students’ characteristics such as discipline, older age and openness to new experiences, extraversion, conscientiousness, agreeableness, teachers’ attitudes and contextual factors such as students’ satisfaction with course quality, workload and clarity of goals are all predictors of deep learning [6].

Another well-established link is between intrinsic motivation and deep learning. Self-Determination Theory (SDT) [10] provides a useful framework to study motivation in students by defining motivation in a continuum ranging from *amotivation* which is the lowest end of the continuum to *intrinsic motivation* which is the highest type of motivation. In *amotivation* on the one end of the spectrum, people do not report any intentionality for the task. *Externally regulation* refers to an external driving force such as getting a reward or avoiding a punishment, *introjected regulation* to an action to cope with internal pressures. If students internalize a reason why they do something, SDT talks about *identified regulation*, if they are interested in the activity itself, this is called *intrinsic motivation*. [11]. SDT further describes that basic needs – ‘energizing states that, if satisfied, conduce toward health and well-being’ that determine these motivation types. SDT reveals three basic needs: autonomy, relatedness and competence. [10, 12, 13]. The basic need of autonomy refers to having meaningful choices and being able to function voluntarily [14, 15]. Whereas autonomy refers to the individual, the basic need of relatedness refers to the need to be connected with others and establish meaningful relationships. Competence finally refers to the desire to experience mastery and to be successful in stimulating situations [14, 16]. Studies have shown a positive correlation between a deep approach and students’ intrinsic motivation [9,17-19].

In order to understand how the USE basic course can be better taught to accommodate the specific learning needs of the abovementioned majors we conducted a study to answer the following questions:

RQ1: Which aspects of the USE Basic course do students of INF/AM and BMT consider interesting?

RQ2: Which aspects of the USE Basic course do students of INF/AM and BMT consider challenging?

RQ3: Are there differences in the 2018 version in students' deep learning and motivation with the course compared to 2017 after the implemented changes?

Methodology

Description of the Ethics and History of Technology course

Our study focused on a course of Ethics and History of Technology provided by a European Technical University for all 2197 first year bachelor engineering students from April to June 2018. Students examined dilemmas from the perspective of history and ethics. For this 11-week course students chose one out of eight cases that involve historical and ethical aspects of technology across 4 topics (Health, Energy, ICT and Mobility). Students worked in multidisciplinary teams on an assignment related to the chosen case. Weekly two hours lectures and two hours tutorials were given. Students had to submit a final assignment at the end of the course counting for 40% of the final grade, make a multiple choice exam, were invited to make 5 interim courses in which the 4 best counted for 10% and finished with a multiple choice exam counting for 50% of the total grade. In ethics, students got peer- and tutor feedback in written format, for history there was an oral peer feedback session and an oral tutor feedback session.

Participants

Students from INF, AM and BMT were invited to participate in the following research activities: a test-run prior to the beginning of the course in 2018 aimed to test new material and documents developed for the course in terms of clarity and interest; weekly observations and informal discussions during the USE Basic course 2018; survey questionnaires during and at the end of the USE Basic course in 2018; and focus groups after the end of the course in 2018.

Qualitative studies

For answering the research questions 1 and 2, a qualitative study was conducted. Table 1 provides an overview of the qualitative data collection methods, the number of participants and the time of data collection.

Together with the qualitative answers that BMT, INF and AM students, who attended the USE Basic Course in 2017, the qualitative study started with a focus group of INF/AM who already took a previous version of the course (2017). The final evaluations were analyzed thematically to identify major challenges that had to be addressed.

In March of 2018, a test run was conducted to test newly developed study material for the upcoming USE Basic Course 2018. In the test run, first year BMT, INF and AM students, who hadn't attend the USE basic course yet, were invited to participate. In a first four hour

session, students were asked to read the study guide and then give their comments. Students then received the assignment material and discussed any difficulties they encountered with the texts and the assignments. In a second four hour session, INF/AM students were given the ICT cases and BMT the health cases. They were asked to start the assignment and then report relevance of the case and difficulties on the assignment.

Table 1. Overview of the qualitative data collection methods

Timing	Method	Number of students
June 2017	Analysis of qualitative answers to open questions of final evaluation USE Basic 2017	129 answers from BMT, INF and AM students
February 2018	Focus group with INF/AM students	2 2 nd year, 2 3 rd year, 2 master students
March 2018	Test run	8 INF/AM and 4 BMT students
During USE Basic 2018 course	Weekly observations/discussions	2 INF and 1 AM students
Week 9 of USE Basic course	Focus groups	6 BMT students
Week 6 and 9	Analysis of qualitative answers to open questions of final evaluation USE Basic 2018	88 answers from BMT, INF and AM students
After course	Interviews with USE teachers	5

All these answers were analyzed thematically. The answers were used for introducing some changes in the USE Basic course from April to June 2018.

During the USE Basic course 2018, three INF/AM students were followed in depth with weekly focus groups and observations. At the end of the course, students also answered as part of the final evaluation of the course two open questions: “What did you like in the course?” and “What would you like to improve in the course?”. These answers were also included in the final analysis of qualitative data. Finally, in-depth interviews were conducted with teachers involved in USE Basic as a way to understand better their learning needs. For answering research question 1 and 2, we transcribed all audio recorded material and analyzed them thematically using the software ATLAS. Two independent researchers analyzed the data and agreed on the identified themes.

Quantitative survey study

In 2018, survey data were collected in week 6 after students completed the history part, in week 9 after completing the ethics part and in week 11 after the end of the course. Questions were asked regarding (a) the learning environment containing nine items about the assignment (see Table 2) measured on a five-point Likert scale, (b) enjoyment with course measured on a five-point Likert scale and (c) students’ approaches to learning which were measured using the Approaches and Study Skills Inventory for Students (ASSIST) [20]. In the

final evaluation students answered the question “On a scale from 1 to 10, how would you rate the USE Basic course?” as well as to provide their feedback about the course.

Table 2. Overview of questions

<i>Learning environment questions</i>	<p>It was clear what was expected in the H/E assignment.</p> <p>The lectures provided clear input for the H/E assignment.</p> <p>The document Assignment Part A/B (H/E) was a help to know what I had to do in the H/E assignment.</p> <p>The activities in the H/E tutorials helped me to make the assignment.</p> <p>The sources provided were helpful to do the assignment.</p> <p>The rubric helped me to understand the ethics assignment.</p> <p>The tutorials provided me with TUTOR feedback that I could use to improve my work.</p> <p>The tutorials provided me with PEER feedback that I could use to improve my work.</p> <p>The collaboration between me and my group members went well</p>
<i>Overall questions</i>	<p>I enjoyed doing the history/ethics part.</p> <p>On a scale from 1 to 10, how would you rate the USE Basic course?</p>
<i>Surface Learning</i>	<p>I often had troubles in making sense of the things I had to study.</p> <p>Often I felt I was drowning in the large amount of material we had to cope with.</p> <p>I was not really sure what was important in lectures or tutorials, so I tried to get down all I could.</p>
<i>Strategic Learning</i>	<p>I organized my study time carefully to make the best use of it.</p> <p>I was pretty good at getting the work done when I had to.</p> <p>I think I was quite systematic and organized when I prepared the assignment and the quizzes.</p>
<i>Deep Learning</i>	<p>Before starting the assignment, I first tried to work out what lies behind it.</p> <p>When I was working on the assignment, I tried to see how all the ideas fitted together.</p> <p>I often reflected on things I heard in the lectures, read in the book or were asked in the tutorials.</p>

In 2017 the same set of questions were asked. In addition, in 2017, students had answered questions about intrinsic motivation, perceived autonomy, and competence. Motivation was measured with a selection of items from the ‘Self-regulation questionnaire – Academics’ [15]. It measured three types of motivation (intrinsic, internalized regulation and amotivation) reduced to two Likert-type items per scale. Table 3 reports on number of students answering the survey questionnaires in 2017 and 2018.

Table 3. Frequencies and response rates of students answering the questionnaire in 2017 and 2018

Major	Year	Questionnaire week 6	Questionnaire week 9	Questionnaire week 11
BMT	2017	14	19	46
	2018	49	21	50
INF	2017	15	14	54

	2018	53	45	79
AM	2017	16	15	28
	2018	10	9	25

Results

Qualitative studies before the course

The qualitative study aimed to identify which aspects of the course BMT, INF and AM students found interesting and what were the major challenges they experienced during the USE Basic course.

The analysis of student answers in 2017 showed that the BMT, INF and AM students share a lot of similarities in their perceptions of the course and the challenges they faced. Students reported significant challenges with USE Basic course. Often all these challenges were described from students as “being out of their comfort zone”. Students discussed extensively which factors might affect their engagement with the course resulting in adopting a surface approach when studying for it.

The factors that affected their motivation and deep approach in learning are summarized in Table 4.

Table 4 Summary of the two main categories of themes identified from the qualitative study in 2017, February 2018 focus groups and March 2018 test run.

Categories	Themes
Category 1. Perceived Relevance	1.1. Perceived relevance of USE Basic with the curriculum
	1.2. Perceived relevance of USE Basic for future profession
	1.3. Negative view and communication of USE Basic in corresponding departments
	1.4. General interest for History and Ethics
Category 2. Satisfaction with course content and implementation	2.1. Clarity of assignment and study material
	2.2. Feedback
	2.3. Working in multidisciplinary teams
	2.4. Difficulty with reading and writing academic skills

1. First category: Perceived Relevance

1.1. Perceived relevance of USE Basic with major curriculum

A common challenge for the BMT, INF and AM students was their difficulty to see the relevance of the USE Basic course, a part of the overall curriculum of their major.

If you know it helps you for the other courses, then I think it's more interesting and more motivational to do it. (BMT student)

The reason that most students did not like this course, including me, was that the subject had to do very little with our bachelor program. Learning history should not be a part of an applied mathematics program. (AM student)

According to students, USE Basic is a course very different from the other courses in their major studies. As a result students are reluctant to engage in deep learning and invest less time and effort in studying and participating in the course activities.

Make it more technical. You are teaching this course at a technical university. We want calculations, proofs and we want to build cool stuff. Not feelings and learning stuff by heart. (INF student)

This is in accordance with teachers' views on the topic. According to them, USE Basic course required taking into consideration multiple subjective perspective, being able to synthesize knowledge from different sources and study material (e.g. academic articles, policy papers etc.). This kind of material and questions are quite different from their major studies.

Some students are used to very exact subjects, exact science, so they are used to exact answers that are verifiable and that is not... we are not good at that is not the case, or at least not in terms of when you talk about such societal subjects. (History teacher)

1.2. Perceived relevance for future profession

When asked about USE Basic course and whether it is a relevant course for their future job, some students did not see how history and ethics would fit to their professional role as engineers.

At this course I learned that, and of course you memorize some nice facts, because in some of the conversations you have later you will memorize; oh wait, that was explained there. But I think information that I'm actually going to use in my field of interest, like Computer Science, not a lot that I didn't already know (INF student)

During the test run, BMT students expressed that they were not interested in the course because they consider their future profession as executors and not responsible for the actions that will be made. INF students got a case of Cambridge Analytica's data analysis and strategic communication. They expressed that they did not consider this interesting. Further questions revealed that they were barely aware of the issue, although it was exactly March 2018 that whistleblower Christopher Wylie informed the media and the issue was hot news for weeks. After explaining what it all was about, students confirmed "Yeah, now I see that it is interesting." (INF student)

1.3. General Interest for History and Ethics

Even though students could not see how history and ethics are important components of their education, they still reported that reading the books and attending some lectures was interesting as it provided them a different perspective to the technology.

I had ethics also in High School and I think both history and ethics are interesting topics as they give you a different perspective for technology. (AM students)

1.4. Negative view of USE in the students' departments

Many of them before even starting the course had already an idea about it from informal discussions with teachers from their own departments and older peers who characterized USE as 'useless'.

When talking to older year students you always hear that USE is not a fun course. It's not hard, but it's not fun. I heard that from pretty much everyone (BMT student)

2. Second Category: Satisfaction with course content and implementation

2.1. Clarity of material and instructions

Students seemed to consider the assignment as central part of their overall experience of USE Basic. Their experience of the assignment was affected by the clarity of the assignment and the clarity of the study material (e.g. study guide or rubric).

For all students' clarity in the course assignment and organization of the study material was considered important. That was especially true for INF students who needed much more structure on how the material was organized and presented. During the focus group with bachelor's and master students, they clearly mentioned this when referring to the need of "baby steps" to explain ethics and history for them. It was considered quite unclear what students had to do and the instructions provided by the tutors during tutorials and the study guide were considered quite vague.

For us, everything needs to be explained very clearly. It has already been explained well, but for us it should be divided even more in baby steps. (2th year INF student)
In the history part you had a lot of facts, but you also had to apply some things, so it was very difficult to see which facts were important and which weren't. And to make a proper text out of them (INF student)

2.2. Feedback

Students also reported that the feedback on their assignment often was neither timely nor very helpful. Between peer and tutor feedback, students preferred the tutor feedback. However, due to the large number of students in each tutorial (approximately 60) students felt that there was not enough time for individual questions.

The feedback session. For both history as ethics you got feedback from your peers. On the ethics part the feedback my group received wasn't much and not really helpful. During the poster presentation of the history part we received just little feedback from our tutor, assuming that all the other parts were okay. But later it turned out that lots of things weren't okay but we couldn't know. (BMT student)

2.3. Working in multidisciplinary teams

Students reported problems with the functioning of their groups as an important demotivating factor. They also suggested a peer review within each group to avoid students doing less in expense of other group members' effort. Despite recognizing the importance of working with students from other disciplines, for the majority of students multidisciplinary at this stage of their learning was an additional burden rather than a learning opportunity. Having to find a "common language" with students from other disciplines, co-ordinate their meetings for project work with all different schedules and commitments seemed like another reason leading to surface approach. The most common strategy for many teams was to simply split

the assignment in parts and putting everything together at the end without really discussing and critically review the assignment as a whole.

Yeah, they approach in different ways. Yeah, I think it would have worked with like different faculties, because it gives a different view on the assignment. But for me, it didn't work. (INF student)

2.4. Reading and writing skills

Many students reported challenges in writing and reading the study material in English even though this is the official language in their major studies too.

This was, honest to god, the most horrible subject that I've ever had to do in my entire life. Please stop forcing technical students to learn history and ethics and writing and reading HUGE texts. Honestly, I am terrible at this, this one of the things that I am just NOT good at, and I had such an awful time during this subject. (INF student)

Teachers mentioned that students differed greatly in their academic skills. Additional support in writing was regarded necessary.

The other difficult element is the huge difference in the level of students in the sense of how literate they are. If you end up in a group with people who have slight problems with reading and writing you are really screwed in this assignment. If you are in a group with people who have more feeling for that, that really helps. I do see that there are huge differences amongst groups. (History teacher)

During the test run, it became clear that the reading skills, especially of INF students, was important in their understanding of the course through the study guide. When asked to read the study guide, they did not look at the text parts at all and only looked at tables and formulas of how the grading was done, clearly indicating surface and strategic learning. When asked for the first learning objective “Students can place science, technology and engineering in a temporal and social context.”, a group of 4 INF students could not give the answer of what was meant here and showed to have problems with words as “temporal” and “social”. Some students even showed a very low knowledge of their own field. In one group of 4 INF students, they were even not aware what *Silicon Valley* was. A last result was that INF and AM students found a LaTeX version of the study guide far more clearly compared to exactly the same version in Word.

Changes in USE Basic course and test run data

After the formative evaluation of 2017, students' feedback from the evaluation of 2017 and the test run was taken into consideration and important changes were:

- In History part, the poster session that was used in 2017 for peer feedback was replaced by written peer feedback that was discussed during tutorials.
- In History part, each group had an individual meeting with the tutor for feedback on the assignment.
- The course lectures were more focused on the different cases and there was a better link between lectures and tutorials.

- The text in study guides was re-written in a clear language and in a concise manner. The study guides were adapted to each case separately and they provided all information and instructions in a clear and linear way.
- A rubric was provided for the history assignment.
- Finally, number of students per group for the group assignment changed from 4 to 6 students.

Comparisons between 2017 and 2018 survey data

The aim was to identify whether there were differences in students' deep learning and satisfaction with the course compared to 2017.

USE Basic overall evaluation

In the question "On a scale from 1 to 10, how would you rate the USE Basic course" no significant differences were reported for BMT and INF students. AM students reported a significant positive increase in their perception of the course. The results are summarized in Table 5.

Table 5. N, mean and standard deviation of students' overall evaluation of the course in 2017 and 2018 ("On a scale from 1 to 10, how would you rate this course?"), together with the mean difference, significance and Cohen's d.

	2017			2018			Differences		
	N	M	SD	N	M	SD	ΔM	sign	d
BMT	46	4.54	2.09	50	5.12	2.04	.58	.175	0.28
INF	54	4.09	2.32	79	3.43	2.07	-.66	.094	-0.30
AM	28	3.75	2.44	25	5.60	1.63	1.85	.001	0.88

Students' perceptions of course content

Table 6 summarizes the significant differences in BMT, INF and AM students' perceptions regarding the learning environment and approaches to learning, for the history and ethics part in 2017 and 2018.

Table 6. Perception of learning environment and approaches to learning for BMT, INF and AM students, for the history (H) and ethics (E) part, together with mean difference, significance and Cohen's d.

		item	2017			2018			Differences		
			N	M	SD	N	M	SD	ΔM	sign	d
BMT	H	Peer Feedback in tutorial	14	1.86	.86	49	2.57	1.04	.71	.020	0.71
	E	Rubric	19	3.21	1.13	21	2.81	.81	-.40	.027	-0.41
		Lecture	19	3.00	.88	21	3.62	.67	.62	.016	0.80
		Ass Doc helpful	19	3.87	.68	21	3.62	.67	-.11	.000	-0.37
INF	H	Teamwork	15	3.80	1.08	53	3.08	1.27	-.73	.031	-0.58

	E	Ass Doc helpful	14	3.46	1.08	45	3.76	1.05	.29	.011	0.28
		Teamwork	14	3.07	1.33	45	2.20	1.25	-.87	.029	-0.69
AM	H	Rubric	16	1.43	.73	10	2.50	.71	1.06	.001	1.48
	E	Rubric	15	2.13	1.25	16	2.50	1.26	.37	.040	0.29
		Deep learning	16	2.10	.62	9	3.04	.716	.93	.002	1.44

BMT students evaluated significantly more positively the peer feedback activities in the history part compared to their peers in 2017. For the ethics part, they evaluated significantly more positively the lectures, the rubric provided as well as the study guides. INF students evaluated significantly more positively the teamwork experience in 2018 compared to 2017 for the history part and for the ethics part they evaluated more positively the study guide and the teamwork. AM student evaluated significantly more positively the rubrics in both history and ethics parts compared to the evaluations of their peers in 2017.

In terms of approaches to learning no difference were found compared to 2017 except for AM students who reported significantly deeper learning (Table 6). Table 7 summarizes the changes in USE Basic course that resulted in a significant difference for at least one of the examined groups. The combination of course redesign measures led to an overall effect for the BMT, ICT and AM groups.

Table 7. Adaptations between 2017 and 2018 that made significant difference for at least one group (BMT, ICT and AM). “0” for non-significant differences; ‘+’, ‘++’ and ‘+++’ for respectively Cohen’s d $d < .50$, $.50 \leq d < .80$ and $.80 \leq d$; same for ‘-’, ‘--’ and ‘---’.

Adaptations between 2017 and 2018 that made significant difference	BMT	ICT	AM
a. History Tutorial: 2017 Peer Feedback in poster session, now peer feedback written and in class	++	0	0
b. Rubric	-	0	+++
c. Lectures: more case based	+++	0	0
d. Ass Doc Helpful in ethics	-	+	0
e. Teamwork: groups of 6 instead of 4	0	--	0
f. Deep learning	0	0	+++

Qualitative data after USE Base 2018

The answers to the open questions included in the final evaluation of the course (in week 11) were analyzed.

Students from all three departments found the content of the course interesting with AM students evaluating more positively the relevance of the course compared to 2017, emphasizing the interesting content of the lectures.

This course focuses on important engineering skills besides your knowledge. (AM student)

The lectures were given in an interesting way, motivating to get to know better the context of history and ethics of technology. (AM student)

In addition, BMT students appreciated the changes in ethics lectures and the connection between lectures and tutorials. Also students seemed to appreciate the discussions that took place during tutorials.

The ethics part was way more interesting than the history part. The ethics part was interactive and by learning different ethical theories, it motivates you to provide your own ethical view on a matter. This leads to meaningful discussion during the assignments. (BMT student)

The criticism of students remained around the topics of feedback, clarity of assignment and multidisciplinary work.

Changes in the peer feedback that were implemented were perceived differently by the students of the different majors. For BMT students changes in the peer feedback process had a positive effect, but on the other hand, ICT students were particularly negative with regard to the feedback that was provided in 2018. AM students did not provide any specific feedback on this matter.

The course was organized much better than other "base" courses which are usually a nightmare. ... Group-to-group feedback was surprisingly very useful. (BMT student)
Peer feedback only works when said peers actually know what they were doing. It was pretty vague what was expected at the group reports, so giving feedback was hard and essentially worthless to the other group. (INF student)

The clarity of the assignment continued being a problem for students despite the effort on revising the study material.

The essay guide is not clear enough on what is expected and the rubrics don't help at all. The thing that helped to do the essay is the tutor explaining what he expects, so either create more guidance in the lectures or the tutorials. (INF student)
Give a more clear explanation the assignments, what is expected from the students and what end product they eventually have to deliver. (BMT student)
Both of the assignments had enough description and explanation, however it was spread across different files in different places of (study guide on canvas, assignment description on canvas, tutor hour slides and slides from the lectures. It was often quite difficult to follow and make sure that all required elements are covered because different aspects were emphasized in one source but totally neglected in others. (AM student)

The change to students' group numbers from 4 to 6 seemed to be significantly more problematic for ICT students, not for BMT and AM. BMT students seemed to like interdisciplinary group work.

The fact that I got to work with student from different studies and work together on projects on use. (BMT student)
Whoever thought the assignment in its current form is a good idea is either childishly naive or dangerously delusional. Forming multidisciplinary teams might sound good but does not work in practice. Putting together serious students from real studies with

students of pseudosciences who much rather prefer being intoxicated than being educated is NOT a good way to set ... (INF student)

Working with groups was nice, however, it wasn't that useful that everyone was from a different bachelor program, so it was very hard to work together outside the USE-hours. (AM student)

Discussion

General conclusions

The focus of this study was understanding better the different needs of 3 majors that traditionally rate the USE basic course with very low grades. The conclusions indicated that the apparent disinterest of INF/TW and BMT students goes far deeper than a uselessness of ethics and history for first-year engineers. It pointed at their way of looking at reality and at their own professional identity. It pointed at the difficulties of general courses to offer educational methods that were interpreted differently from student groups of different departments. And it pointed at differences at basic competences needed to dive into deep learning and to be motivated by what is offered by the course.

The qualitative evaluations before the course suggested that students overall faced several challenges during the courses that led to decreased satisfaction with it, low motivation and a surface or strategic approach to learning [4]. Students found the course content and course assignments unclear. In addition, they perceived feedback as insufficient and they found the content of the course either uninteresting or unrelated to their studies. This led to low intrinsic motivation and high amotivation (see also [21]).

The redesign realized several significant changes. Emphasis was put in making the study related material more clear and concise for students. That seemed to have a positive effect for the students' perceptions about the course as the only significant changes in students' perceptions were related to study material like study guides, rubrics and the perception of teamwork. It is possible that the additional time teachers spent to discuss with students did not lead to more understanding with regard to the content of the course but also provided more time to address team related problems.

Among the strongest results are that BMT students appreciated the lectures more; INF students appreciated the teamwork less and AM students engage more in deep learning. It is possible that for INF students, the changes with regard to the clarity of material was enough while for BMT students and INF other challenges like the perceived relevance and the difficulty with academic skills remained unaddressed.

Table 8 however showed that these differences are very scattered and that overall redesign changes are not per se answering the different needs of the students at the same time. This is of course a very challenging conclusion for redesigners trying to cope with student differences. Changes should be such that they are good for the most needed students, but also for all the others.

In this study, considerable differences on how needs are (not) addressed by the educational methods used and how this affects engagement and evaluation of the course, deep learning and motivation were discussed. In accordance with current literature, this study stresses the importance of understanding the differences in students' learning needs as a way to promote deep learning [5,6,9]. Making changes in the learning environment might not be sufficient,

especially in courses where students from many disciplines are represented and thus students' individual differences should be taken into consideration [9]. Interest in the topic and understanding the relevance of the course seems to be of particular importance for students [19]. A way to foster interest is by providing more structured knowledge and clarity [17,18], that can lead to deep learning [22]. Providing support for academic skills is also very important as lack of competence in reading and writing can also affect some students' motivation to engage with the material [5,6].

The analysis also revealed more profound challenges that could not be addressed in the short term. One of these insights is definitely the INF students' way of getting information about societal aspects. As students were not aware of *Cambridge Analytica* issues at the moment they were all over in the news and some of them even did not know about *Silicon Valley*, the approach should be strongly adapted. Teachers in the USE Basic course should much more pay attention to the different knowledge levels of the different students. Cases that are core to students' discipline should not be expected to be known and brought in step by step in order to be activating for students.

Limitations

We indicate some limitations of our research. Initially, the sample sizes in the survey study are small and might not be representative to the population of the BMT, AM and INF departments. The students who participated in the qualitative study were also quite motivated to share their views about the course. The very unmotivated and uninterested students towards USE basic did not answer the invitations to participate. In addition, the qualitative study did not aim to examine in depth the learning approaches of students but rather acquire a first understanding of what they find interesting and what is difficult with the USE Basic course. Future studies should aim to go more in-depth and see how students from different disciplines approach the learning material differently.

Designing future steps

This study builds on insights about student differences. Further research, however, should look at overall course changes that will be useful for all students, since major specific differences are not possible in this course. Cases will be developed about topics that are of interest for the different students. This will be done in collaboration with teachers from students' major departments to increase the chance of success. The real-life cases will involve real stakeholders that are considered experts by the students and will bridge the gap between the technical content they are interested in and the historical and ethical aspects. Online tutorials on reading and writing will be provided to assist students' academic skills. A feedback platform will be used to facilitate peer and teacher feedback. More time during tutorials will be given for individual feedback for each team. Finally, students will have the possibility to form their own groups as a way to minimize the negative perceptions of students with regard to teamwork. Future research will be needed to assess whether such an extensive redesign of the course can also have a positive impact on students' learning and motivation.

References

- [1] S. Roeser, "Emotional Engineers: Toward Morally Responsible Design," *Sci. Eng. Ethics*, vol. 18, no. 1, pp. 103–115, Mar. 2012.
- [2] R. M. Felder and R. Brent, "Understanding Student Differences," *J. Eng. Educ.*, vol. 94, no. 1, pp. 57–72, 2005.
- [3] R. Bekkers and G. Bombaerts, "Introducing Broad Skills in Higher Engineering Education: The Patents and Standards Courses at Eindhoven University of Technology," *Technol. Innov.*, vol. 19, no. 2, pp. 493–507, 2017.
- [4] G. J. T. Bombaerts, K. I. Doulougeri, A. Spahn, N. M. Nieveen, and B. E. U. Pepin, "The course structure dilemma: Striving for Engineering students' motivation and deep learning in an ethics and history course," in *Proceedings of the 46th SEFI Annual Conference 2018 : Creativity, Innovation and Entrepreneurship for Engineering Education Excellence*, 2018, pp. 79–87.
- [5] A. Parpala, S. Lindblom-Ylänne, E. Komulainen, T. Litmanen, and L. Hirsto, "Students' approaches to learning and their experiences of the teaching–learning environment in different disciplines," *Br. J. Educ. Psychol.*, vol. 80, no. 2, pp. 269–282, 2010.
- [6] L. Postareff, A. Parpala, and S. Lindblom-Ylänne, "Factors contributing to changes in a deep approach to learning in different learning environments," *Learn. Environ. Res.*, vol. 18, no. 3, pp. 315–333, Oct. 2015.
- [7] F. Marton and R. Säljö, "On Qualitative Differences in Learning: I—Outcome and Process*," *Br. J. Educ. Psychol.*, vol. 46, no. 1, pp. 4–11, 1976.
- [8] N. J. Entwistle and E. R. Peterson, "Conceptions of learning and knowledge in higher education: Relationships with study behaviour and influences of learning environments," *Int. J. Educ. Res.*, vol. 41, no. 6, pp. 407–428, Jan. 2004.
- [9] M. Baeten, E. Kyndt, K. Struyven, and F. Dochy, "Using Student-Centred Learning Environments to Stimulate Deep Approaches to Learning: Factors Encouraging or Discouraging Their Effectiveness," *Educ. Res. Rev.*, vol. 5, no. 3, pp. 243–260, 2010.
- [10] R. M. Ryan and E. L. Deci, "Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being.," *Am. Psychol.*, vol. 55, no. 1, p. 68, 2000.
- [11] R. M. Ryan and E. L. Deci, "Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions," *Contemp. Educ. Psychol.*, vol. 25, no. 1, pp. 54–67, Jan. 2000.
- [12] E. L. Deci and R. M. Ryan, "The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior," *Psychol. Inq.*, vol. 11, no. 4, pp. 227–268, 2000.
- [13] R. M. Ryan, "Psychological Needs and the Facilitation of Integrative Processes," *J. Pers.*, vol. 63, no. 3, pp. 397–427, Sep. 1995.
- [14] M. Vansteenkiste and W. Lens, "Intrinsic versus extrinsic goal contents in self-determination theory: Another look at the quality of academic motivation," *Educ. Psychol.*, vol. 41, no. 1, pp. 19–31, WIN 2006.
- [15] M. Vansteenkiste, E. Sierens, B. Soenens, K. Luyckx, and W. Lens, "Motivational Profiles From a Self-Determination Perspective: The Quality of Motivation Matters," *J. Educ. Psychol.*, vol. 101, no. 3, pp. 671–688, Aug. 2009.
- [16] J. Reeve and H. Jang, "What teachers say and do to support students' autonomy during a learning activity," *J. Educ. Psychol.*, vol. 98, no. 1, pp. 209–218, 2006.
- [17] E. Kyndt, F. Dochy, K. Struyven, and E. Cascallar, "The direct and indirect effect of motivation for learning on students' approaches to learning through the perceptions of workload and task complexity," *High. Educ. Res. Dev.*, vol. 30, no. 2, pp. 135–150, Apr. 2011.
- [18] S. Hidi and K. A. Renninger, "The Four-Phase Model of Interest Development," *Educ. Psychol.*, vol. 41, no. 2, pp. 111–127, Jun. 2006.

- [19] J. Mikkonen, A. Heikkilä, M. Ruohoniemi, and S. Lindblom-Ylänne, “‘I Study Because I’m Interested’: University Students’ Explanations for Their Disciplinary Choices,” *Scand. J. Educ. Res.*, vol. 53, no. 3, pp. 229–244, Jun. 2009.
- [20] N. Entwistle, H. Tait, and V. McCune, “Patterns of response to an approaches to studying inventory across contrasting groups and contexts,” *Eur. J. Psychol. Educ.*, vol. 15, no. 1, p. 33, Mar. 2000.
- [21] G. Bombaerts and P. J. Nickel, “Feedback for relatedness and competence: Can feedback in blended learning contribute to optimal rigor, basic needs, and motivation?,” in *Global Engineering Education Conference (EDUCON)*, 2017 IEEE, 2017, pp. 1089–1092.
- [22] E. Kyndt, F. Dochy, K. Struyven, and E. Cascallar, “The perception of workload and task complexity and its influence on students’ approaches to learning: a study in higher education,” *Eur. J. Psychol. Educ.*, vol. 26, no. 3, pp. 393–415, Sep. 2011.