

The SEFI Francesco Maffioli Award of Excellence for Developing Learning and Teaching in Engineering Education

The SEFI Francesco Maffioli Award, launched by SEFI to commemorate its late President Prof. Francesco Maffioli (Politecnico du Milano), is given by SEFI, the Société Européenne pour la Formation des Ingénieurs, to individual teachers, or a team of teachers, of higher engineering education institutions members of SEFI, in recognition of **open-minded development of curriculum, learning environments or tools, novel didactics, methods or systems in engineering studies.**

Gunter Bombaerts - Challenge-based learning to improve the quality of engineering ethics education

I wish to award Gunter Bombaerts for his continuous open-mined development of a large and multidisciplinary first-year ethics and history of technology course (“USE basic course”) at TU Eindhoven, the Netherlands.

Background

Improving the quality of Engineering Ethics Education for first-year students is very important, as it indicates that ethics is an intrinsic part of their training program. I know that this is also an important struggle shared all over Europe (see the upcoming SEFI Ethics SIG 2021 workshop “Comparing institutional strategies for engineering ethics education in regional, national and European contexts”¹).

Sources of inspiration

Gunter redesigned the course in an evidence-informed way. Sources of inspiration were for example self-determination theory^{2,3}, curricular spider-web⁴, case-based learning⁵, action research⁶, challenge-based learning^{7,8} (CBL), curriculum quality⁹ and responsibility¹⁰.

Applied teaching methods

As said before, I wish to nominate Gunter for his continuous effort, together with many others, in redesigning the USE basic course. He started at TU/e in 2014 as coordinator of the Eindhoven “USE” program, aiming to increase students’ awareness, knowledge and attitudes of the links between User-Society-Enterprise aspects of technological innovation¹¹.

Standard Course

As the course evaluations showed that students’ motivation for the course was low, Gunter and colleagues analysed motivational issues using self-determination theory in 2016. As reported in EJEE¹¹, they found that students 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 (see most pronounced arrows in the figure below).

Fig1: Analysis USE basic course 2016

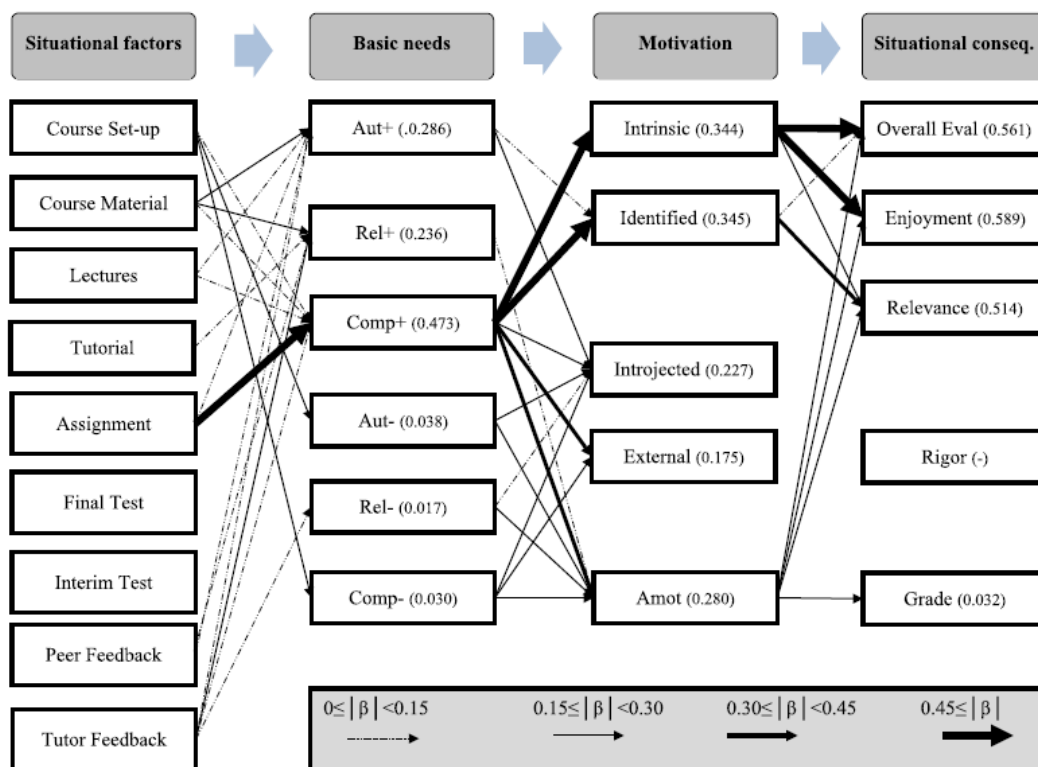


Figure 2. Overview of Stepwise Linear Regressions in Vallerand’s model. Basic needs predicted by course elements, motivation types by basic needs and course outcomes by types of motivation. R^2 between brackets. $|\beta|$ divided in four groups: $0 \leq |\beta| < 0.15$; $0.15 \leq |\beta| < 0.30$; $0.30 \leq |\beta| < 0.45$; and $0.45 \leq |\beta|$.

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. They 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). 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.

Fig2: CBL in 2019

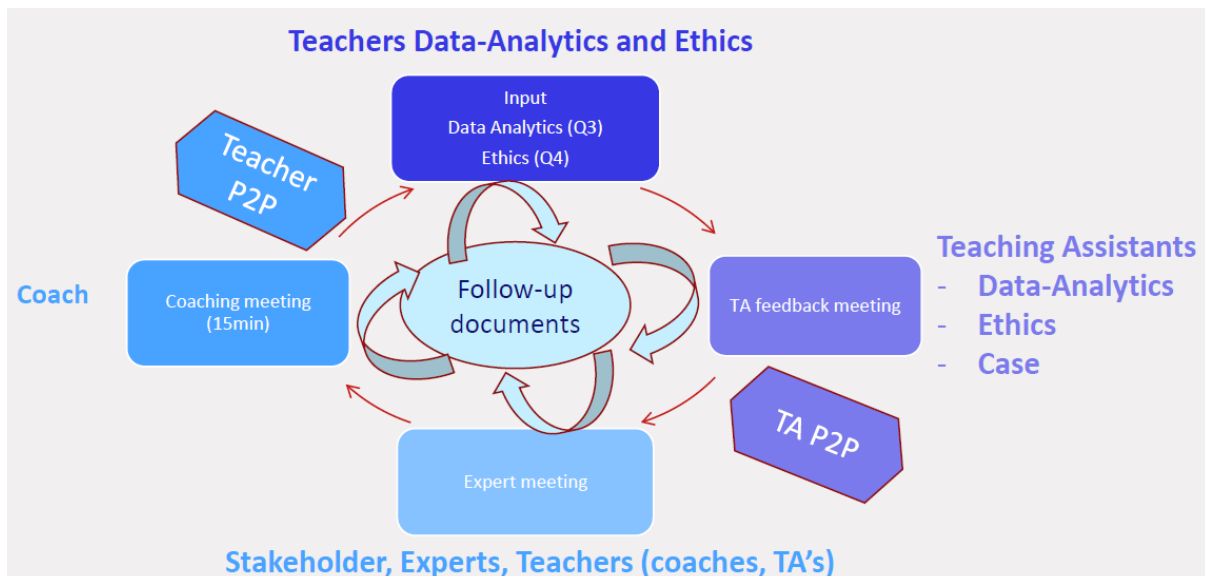


CBL 2.0

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 aspect. 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-centered 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 TA’s to support their work and a weekly meeting with the teachers to evaluate the previous week and plan the next week.

Figure3: Weekly cycle E³-challenge2 course.



Results and impact

Gunter used an evidence-informed approach analysing many aspects of the course (see for example¹²⁻¹⁸). Here I briefly want to refer to an upcoming article in *Journal of Science and Engineering Ethics*, in which Gunter and his colleagues compare the 2019 CBL version with a non-CBL 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 framework¹⁹ could not confirm that.

Table 2: The number of respondents (N), means (M), standard deviations (SD), differences in means (ΔM), significances and Cohen's d effect sizes (d) for the factors of interest for the case-based learning (CBL) and detached course approach at end of course (week 9).

Item/Factor	CBL			Detached			Difference	
	N	M	SD	N	Mean	SD	$\Delta M(\text{sign})$	d
Enjoyment	57	4.02	0.79	58	2.98	0.93	1.04***	1.20
Overall evaluation	57	7.48	1.22	56	6.50	1.74	0.95**	0.63
Autonomy	55	4.27	0.63	55	3.99	0.64	0.28*	0.45
Competence	55	3.85	0.82	55	3.24	0.88	0.62***	0.73
Relatedness	55	4.01	0.63	55	4.02	0.76	-0.01	-0.02
Intrinsic motivation	54	3.38	0.77	54	2.76	0.97	0.62***	0.71
Identified regulation	54	2.06	0.97	54	2.93	1.07	-0.87***	-0.85
Amotivation	54	3.01	0.80	54	2.19	1.18	0.81***	0.81
Acqa2_reformulate	53	3.93	0.58	54	3.67	0.71	0.28**	0.44

*p<0.05, ** p<0.01, *** p<0.001

For the E³-Challenge2 course, three post-doctoral researchers performed many observations, but results are not yet available.

Engineering Education Significance and Dissemination

CBL is seen as promising for engineering education in general and ethics engineering education in particular. Gunter and colleagues take an active role in creating dynamic on these topics. Here some of his contributions:

- He is active in the EU [SCALINGS](#) project studying co-creation in general and the link with co-creation education in particular. He coordinates a peer-to-peer session with TUM Germany, DTU Denmark, UEW Poland, ESADE Spain, University of Troyes France, Imperial College London UK.
- Together with the involved PhD students, he made a [video](#) (more than 2k views at the moment)



- He collaborates with Christian Herzog in a [fellowship Hochschulehre 2020](#).

- He advised the project learning commission EPFL Switzerland.
- He held several SEFI workshops on ethics-CBL, like the 2019 SEFI ethics SIG meeting and a SEFI workshop in 2019²⁰.
- He spoke in the Dublin “Exploring Ethical Concerns in Electronic and IT Engineering Education” [workshop](#).
- He collaborates in an Erasmus+ project [EuroTeQ](#) supporting CBL in Tallin University Estland, TU Prague Czech Republic, TUM, DTU, EPFL, l’X Paris France, and Technion Israel.
- He wrote several articles on the subject (see list below).

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