4TU. CENTRE FOR ENGINEERING EDUCATION

Progress Report 2017 - 2018

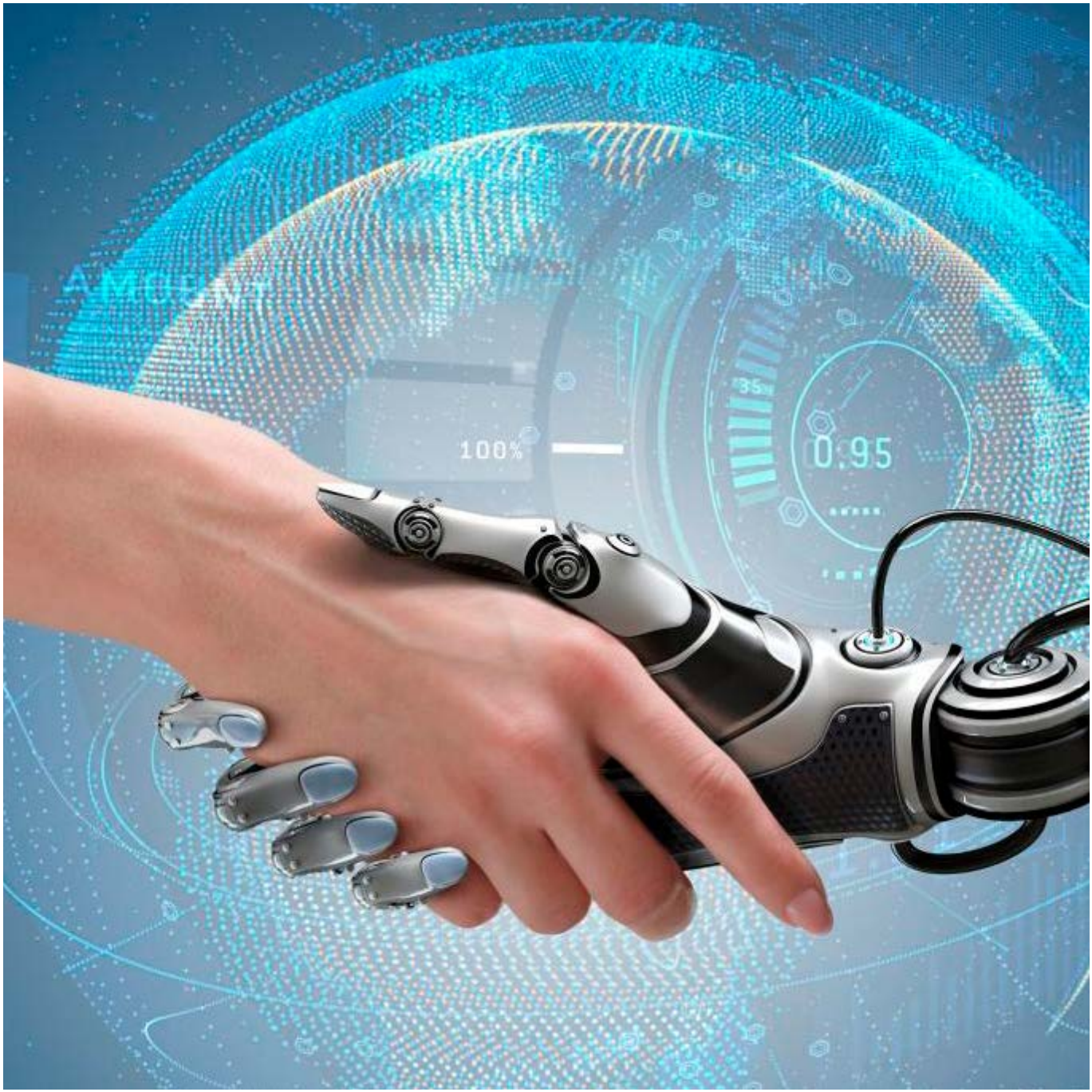
TU Delft Delft University of Technology

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

UNIVERSITY OF TWENTE.

WAGENINGEN UNIVERSITY & RESEARCH

'Innovating engineering education for tomorrow's engineer'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Introduction

Recognition and visibility

Before you lies the 4TU.Centre for Engineering Education (4TU.CEE) progress report 2017-2018. During the past two years, 4TU.CEE has evolved from a starting centre of expertise as part of the sector plan for engineering, into a stable, recognised and mature centre. In 2017, Wageningen University and Research (WUR) joined the other 3 technical universities, and also became a fully involved member of the Centre, turning it from 3TU.CEE into 4TU.CEE. The past two years, 4TU.CEE invested in a variety of themes: future engineering skills, curriculum development, interdisciplinary engineering education, emerging technologies, engineering education for all (sustainable engineering education) and teaching excellence. Especially the number of workshops and activities for teachers were expanded, but at the same time many new research projects were started. In this report, you will find a selection of highlights under each of the mentioned themes.

In October 2018, Jan van der Veen stepped down as 4TU.CEE chair. Under his chairmanship 4TU.CEE became the successful centre it is today. Hence, 4TU.CEE owes much gratitude to Jan, who continues to be involved as local 4TU.CEE leader of Twente University. Since October 2018, Perry den Brok (WUR) took over the role of chair.

"In a short period of time, 4TU.CEE has established a visible position nationally and internationally, and has received international recognition for its work."

Frank Baaijens, rector magnificus TU/e & chair of 4TU

The Centre was active at both the national and international level. For example, the Dutch national research organisation NWO – via the educational subsector NRO – used 4TU.CEE as an example for its new plans to launch an innovation portal and associated network in higher education. 4TU.CEE organised the 2nd National conference on Interdisciplinary Education (NIE) in Eindhoven in 2018. Internationally, 4TU.CEE organised a meeting for CDIO (Conceive, Design, Implement, Operate) in Delft, and the SEFI 2020 (European Society for Engineering Education) conference will be organised by 4TU.CEE with other local partners in Enschede!

Activities and outcomes

4TU.CEE organised many activities and was involved in a variety of projects, both small scale as well as larger scale. International scholars were invited for workshops and lectures, amongst them were Kristina Edstrom (KTH), Donald Carpenter and Andrew Gerhart (Lawrence Technical University), Babi Mitra (Massachusetts Institute of Technology) and Ruth Graham (Royal Academy of Engineering, UK). Furthermore, workshops were given by local staff of the 4 TUs on topics such as supervising interdisciplinary engineering projects, virtual and augmented reality in engineering courses, future engineers, to name but a few. Educational innovation days were held, and presentations were given by 4TU.CEE sponsored staff at national and international conferences (see the research output in the appendices).
4TU.CEE projects resulted in new frameworks, redesigned courses, educational apps, guidelines, digital resources and so on. The 4TU.CEE online Innovation map is an important source of information for teachers and education support staff where output of our projects can be found. It exists

for a few years already. It was originally developed in Eindhoven and has been updated in 2018 with some focus points: improved usability (faster loading, better navigation, easier search) and optimised search results in google. The renewed Innovation map will be live in April 2019. As per September 2018, 179 projects are featured in it, in which 242 researchers are involved.

A larger variety of university teaching staff was involved in 4TU.CEE activities, both via workshops as well as in 4TU.CEE sponsored or monitored innovation calls (at TU/e and WUR), or supervised by 4TU.CEE experts in for example senior educational qualification projects. During 2017-2018, new PhD students started with their projects (a list of 4TU.CEE funded or supervised PhD projects can be found in appendix 3). Also, the first 4TU.CEE sponsored PhD candidate finished her dissertation: Inken Gast (University of Twente) obtained a PhD with a project on teacher design teams in engineering education. One of the chapters of her dissertation, a review study, was also published in the highest ranked journal in the educational domain: Review of Educational Research! Currently, 4TU.CEE is working to strengthen its international network, and special attention is given to PhD students as well.

"Engineering education in the Netherlands has a fine reputation and 4TU.CEE has been instrumental in starting, stimulating and increasing the visibility of truly significant work. By joining forces on the national level, this has become a model for furthering engineering education in any country."

Kristina Edström, KTH Sweden

Outlook to the future

The Centre has also just launched its strategic plan for 2019 to 2021. In short, in the upcoming years 4TU.CEE will focus on a smaller set of themes – Educating future engineers, Interdisciplinary engineering education, Engineering educational ecosystems, and Teaching excellence in engineering education – but will do so more in-depth. We will also intensify our collaborations, both within 4TU.CEE as well as with other partners. We will, for example, jointly participate in the Framework for excellence in teaching project by Ruth Graham. At the same time all 4 TUs will also become member of the earlier mentioned organisations CDIO and SEFI. While we will continue to deliver practical tools and insights and give inspiration to teachers, we also expect our scientific outcomes to grow, as more PhD students will finish their dissertations and more projects will result in both practical and scientific publications.

I would like to thank all university staff and national and international partners of 4TU.CEE. A word of appreciation goes to the dedicated 4TU.CEE leaders and programme coordinators. Thanks in particular to past UT programme coordinator (2014-2017) Lisa Gommer, who is now Director of Education of the Mechanical Engineering bachelor and master at the University of Twente. She remains a partner of our extensive network in engineering education. It is to a considerable degree via the efforts of all of these people that so much has been achieved. Hence, I proudly present you the 4TU.CEE 2017-2018 progress report! I wish you much pleasure and inspiration reading it, and we hope to continue to collaborate with you in the upcoming years!

Prof. dr. Perry den Brok, chair of 4TU.CEE

Contents

4TU.CEE mission, vision & strategy

Mission

To jointly inspire, stimulate, support and disseminate effective and high quality Engineering Education through research and application of evidence-based innovations within the Engineering Education domain.
4TU.CEE is the place for teachers and scientists with questions and ambitions in the domain of Engineering Education.

"Innovating engineering education for tomorrow's engineer"

Vision

The world needs more and differently educated engineers who are geared to the grand societal challenges in the areas of energy, health, mobility, safety and environment. 4TU.CEE contributes to inspiring and effective engineering education within the Netherlands as well as abroad to prepare the student for tomorrow's challenges.

Strategy

4TU.CEE fulfils this mission with the following strategies:

- Mapping recent innovations, trend, tools and (didactic) insights from the engineering education domain at 4TU and keeping these overviews up to date;
- Tracking and counselling engineering education innovations at 4TU, if part of 4TU.CEE;
- Pitching and initiating own (accompanying) research on the development and functioning of innovative engineering education at 4TU;
- Disseminating tools, research results and best practices via the 4TU.CEE website and participating in or organising events, congresses and contributing to journals;
- Organising events for teachers, focused on the exchange of knowledge and experience within the engineering education domain and offering inspiration and support;
- Setting up and maintaining an international partnering network in the engineering education domain.

Reading guide

In the upcoming pages, you will read a selection of activities and projects, conducted during 2017 and 2018. These activities and projects are structured under the following themes: (1) future engineering skills, (2) curriculum development, (3) interdisciplinary engineering education, (4) emerging technologies, (5) engineering education for all, and (6) teaching excellence. Per theme, we will provide a short description of the theme and a selection of flagship activities conducted under that theme. We do not claim to be complete in our overview of mentioned activities or persons involved in these projects in this report. However, a more detailed overview of activities and projects, as well as people involved in them, can be found at the 4TU.CEE innovation map on the 4TU.CEE website. In the appendices, an overview of output is given, as well as an overview of PhD projects. We will also provide some facts and figures concerning our impact. To keep track of interesting 4TU.CEE activities and project results, we invite you to subscribe to our electronic newsletter, join our 4TU.CEE LinkedIn group, visit our 4TU.CEE blog and of course the 4TU.CEE website!

1. Future engineering skills

The implementation of future engineering skills in engineering education, and entrepreneurial behaviour in particular, is an important topic of interest. The future engineer needs, apart from a sound knowledge base in a specific engineering domain and related domains, personal and professional skills in order to engineer solutions for the grand challenges in society and bring engineering products to the public and politicians. These skills are diverse, but include creative thinking and collaborating in multidisciplinary teams. Other skills are so-called entrepreneurial thinking and -acting skills, such as risk taking (dealing with uncertainty, ambiguity and risks), problem solving and leadership or team building. 4TU.CEE focused on how to integrate such skills in engineering education, in which attention was also paid to new teaching and learning methods and new learning spaces.

Vision on Engineering Education

Aldert Kamp, 4TU.CEE leader of TU Delft renewed his publication "Future Vision on Engineering Education", describing different roles and skills for engineers and how to implement these in curricula, and found much resonance in numerous external stakeholder groups. In particular, CESAER (the European association of leading specialised and comprehensive universities of science and technology) has asked to contribute to the European white paper on engineering education for the future. Aldert will provide a key note on the ASEE 2020 to share his views and his extensive work in this area.

Another example in which future engineering education and research on educational innovations in engineering education was described was the symposium and inaugural lecture of Perry den Brok (WUR), entitled 'Educating future graduates in the life sciences: on the role of educational ecosystems' (2018). Ruth Graham delivered a 'Future of Engineering Education' keynote to the UT week of inspiration in November 2018, building on her state-of-the-art study commissioned by MIT.

"We have to empower academic teaching staff to improve and innovate, teach them the values to be a role model for engineers, and educate them to understand the relevance and importance of societal implications of engineering education"

Comment on white paper drafted by Aldert Kamp from participant CESAER Workshop "Pedagogical and technological innovations in education" in Bucharest, October 2018.

Crowdsourcing

In a crowdsourcing project TU/e researched the possibilities to integrate real life crowdsourcing projects into an engineering course. Students and faculty reacted positively towards the proposition of integrating this into education. An important criterion found for students and faculty when selecting crowdsourcing tasks to fit within design education was "matchmaking" between available tasks and a student's profile. This finding led to the development of a recommender system (among others) that aims to be the virtual matchmaker. Students and teachers can choose challenges from this system. Many of these challenges are paid by the companies. A rather surprising result was that it is not money, but the task experience itself, which was the greatest motivator for students. Students perceived the prize as an added bonus for putting in hard work, but they claimed to get their main motivation from working in real-life projects.

Innovative learning spaces

TU/e made an inventory of practical and scientific questions on the topic of innovative learning spaces. The outcomes were presented in a paper at the SEFI conference in September 2018 together with TU Delft and UT. This analysis was a first step to share such knowledge amongst the 4TU institutes and beyond. The next step in the upcoming years is to build a network of faculties engaged in these learning spaces and to learn from each other. Also, within the CDIO network there is currently a special interest group looking specifically at the learning gains of the innovative learning spaces, with strong involvement from 4TU.CEE. This will be presented at the CDIO conference in Aarhus in the summer of 2019. Within TU/e, a post doc researcher is hired to research assessment of challenge based learning. At UT a study was conducted to make learning spaces more student driven in collaboration with the design lab. Students were also involved in the research and redesign of Twente's Classroom of the Future, combining forward thinking with very practical suggestions.

Engineering roles

A MOOC for Professional Education has been developed in collaboration with the Career Centre TU Delft and support of Teaching and Learning Services (TLS). The MOOC is intended for engineers who are ready for the next step in their career and do not quite know how to move on. After our 3rd run participants are in general very satisfied. What was also helpful was that it was a career course especially for engineers.

"This course helped me to get a clear picture on how my ideal job looks like. What really helped me was that the course made me act instead of being unsatisfied and not knowing what to do".

"It felt like the people who set up the course wrote it especially for me."

Previous learner *(*senior system engineer)

2. Curriculum development

On the topic of curriculum development 4TU.CEE has been involved in implementing changing engineering roles and profiles in the curriculum and has looked at the team-based approach in curriculum innovation. Engineering curriculum and course designs have been mapped at institutional, programme and course level. A framework has been developed that can guide workshop sessions of a multidisciplinary nature (Curriculum Think Thank, Delft). An important question is how the roles and profiles, personal and professional skills that gain in importance in the future, can be integrated in our disciplinary education. In collaboration with academic and professional stakeholders we explored future trends and defined potential scenarios in society, engineering and technology. Many new courses have been designed and implemented by teams of teachers. This team-based approach offers opportunities for new multidisciplinary approaches.

Visions on Engineering Education and Engineering Roles in the future Personology Arena

The engineering roles for the future have currently been developed into 'The Personology Arena', a concept design for the future engineering university. This concept has been developed in a design team, with professional guidance from Prof. Matthijs van Dijk, Chair of Applied Design at TU Delft. Along the way several workshops were held to assess the validity of the newly designed concept with different stakeholders, amongst others at the Dutch Design Week in Eindhoven and at TU Delft. Results were disseminated at the CDIO conference 2017 and 2019. At the moment a booklet is being assembled to distribute the concept amongst a wider audience. These activities will be followed up by research into professional preparation for different engineering roles, a framework for design roles in the concept and the making of a blue print for embedding the concept into the TU Delft master education.

Mind the Gap / Bridge the Gap

At the University of Twente Maaike Endedijk, Ruth van Veelen, Natascha van Hattum and colleagues researched the career choice of science and engineering students by zooming in on professional identity profiles. Profiles of students and young professionals were compared in a large-scale set-up (Tech Your Future) with many industries involved. Follow-up work commissioned by 4TU.CEE is targeting TU/e, WUR and UT engineering students while also

working on the industry side. Goals are to (1) raise student awareness of career options, to (2) prompt companies to widen the profiles that could fit their workforce, so as to (3) raise the percentage of engineering students that pursue a career in the technology sector (now only 44%).

4TU meets MIT

Dr. Amitava Babi Mitra of the New Engineering Education Transformation (NEET) of MIT visited TU/e on 17 May 2018. All 4 technical universities presented their institutional visions on engineering education of the future, as did MIT. All 5 universities recognised that 21st century engineering students need more than specialist knowledge alone to be able to work in this fast changing world. They need a wider skills set than their predecessors: skills like creative and entrepreneurial thinking and the ability to communicate with the outside world, for example. These are topics the universities are all currently working on by providing flexibility in their education programmes, more hands-on education and by offering interdisciplinary education.

"Especially the first year in University is hard for students. They get bored and do not know why they learn what they learn."

Babi Mitra

Team based design of engineering education

When implementing a curriculum innovation, teachers play a central role, as they are the ones who have to implement the innovation in practice. Teacher professional development is therefore crucial for curriculum innovation to be successful. At the University of Twente teachers are now expected to work together in teams while designing and implementing modules. Although team work becomes increasingly common in higher education, collaborating on teaching matters was new to many teachers when the new Twente Education Model started in 2013/2014. Inken Gast studied this process right from the start of the curriculum innovation. She finished her thesis in 2018 and found that team leaders play a crucial role as in-depth discussions can lead to improved modules and professional development of the team members at the same time. Rike Bron worked in parallel on her PhD, researching how teachers in those teams communicate, also across different teams. She is expected to defend her thesis in 2019. Both Inken and Rike shared their observations and findings extensively with directors of education and other staff involved in curriculum innovation.

3. Interdisciplinary engineering education

Interdisciplinary education has been a focus point of 4TU.CEE since the start of the Centre. It is about solving problems that draw on multiple disciplines, either within the engineering domain or between the engineering domain and domains outside of engineering. It is about integrating information, data techniques, tools, perspectives, concepts and theories from two or more disciplines. Interdisciplinary learning is one of the central characteristics of both contemporary engineering education and design-based education. 4TU.CEE particularly looked at the integration of maths and physics, the design of a framework for interdisciplinary education and the assessment of interdisciplinary skills.

Interdisciplinary Learning

In November 2018, a group of some 40 staff from all 4 universities gathered for a two-day workshop to discuss and work on interdisciplinary education. It was guided by Prof. Siddhartan Govindasamy and Prof. John Geddes from Olin College, where almost all education is interdisciplinary. Olin is considered as one of the leading institutes in engineering education by Ruth Graham. The workshop was an excellent meeting ground for 4TU teaching staff to exchange on the complexities of interdisciplinary teaching and learning, and the future of engineering education. The teaching staff found it extremely useful to exchange on problems they encounter in higher engineering education in the Netherlands.

> *" I liked the atmosphere and the open discussions, the thoughts and the opinions and the exchange of experiences with colleagues from 4TU and experts from Olin"*
>
> Workshop participant

Learn more about this workshop by reading the 4TU.CEE blog. 4TU.CEE has decided to continue this exchange in a linkedIn group.

> *"We really appreciated hearing about your projects and your perspectives on engineering education, and working with you. You are doing some very exciting and interesting work."*
>
> John Geddes and Siddhartan Govindasamy

The Joint Interdisciplinary Project

In 2017 and 2018 the Joint Interdisciplinary Project (JIP) has run at TU Delft with participants of 5 faculties and different engineering companies in the Netherlands. As it has been well received, the master elective will be scaled up to 60 students this year and eventually grow to 600 students.

Companies, faculties and students are already lining up to participate in this innovative interdisciplinary elective where students under guidance of a company coach work on real life engineering problems. Academic staff and expertise can be consulted to realise the best possible results. More on JIP can be found at the 4TU.CEE website.

" I've learned so many things during the course that would never have been possible through any course at the university. The JIP program gave me insight into the current industry trends and acted as the stepping stone in identifying my interests which further lead me to determine the topic of my master's thesis."

JIP participant

High Tech, Human Touch modules

In 2018 Danielle Kuiphuis and Karen Slotman researched 10 interdisciplinary modules at the University of Twente that students from all programmes can take in their third year. This includes modules such as Science2Society in which student teams design solutions for societal partners. Interdisciplinarity is something that not 'just happens' but requires hard work and careful design from the teacher teams involved. Also, students have to go the extra mile to work as a team and develop a shared understanding of the interdisciplinary problem while building on each other's strengths.

Interdisciplinary research

A team of researchers of all four universities engaged in a literature review on engineering education as well as a review of interdisciplinary courses at each of the universities. Research on one Delft case has led to a first journal paper in the European Journal of Engineering Education (2018). Currently, the interdisciplinary minor and masters are investigated via interviews with programme coordinators and first results will be presented at the Research in Engineering Education Society conference (2019). A second case study in the context of the Technical Medicine programme of the University of Twente was recently published by Mieke Boon and Sophie van Baalen in the Medical Teacher journal illustrating that being able to work in interdisciplinary engineering/medicine contexts includes the ability to combine different disciplinary perspectives. Eventually, the research results will be translated into a handbook on design for interdisciplinary education. Naturally, the Joint Interdisciplinary Project (see page 14) will feature as one of the cases to learn from. Another 4TU.CEE literature review conducted by Van den Beemt et al. is currently under review by a journal. In this review we analyse studies exploring interdisciplinary courses and curricula in higher engineering education. We aim to offer an integrated view on interdisciplinary engineering education (IEE), which supports both IEE related research and practice. Preliminary results of this study were also presented at local innovation days. Research done by UT researcher McLeod resulted in two publications: 'what does interdisciplinarity look like in practice' (Studies in history and philosophy of science) and 'what makes interdisciplinarity difficult' (Synthese).

Conference on Interdisciplinary education

On 30 January 2018 the second National Interdisciplinary Education Conference took place at TU/e. The event attracted almost 100 participants. During this event general and technical universities from the Netherlands and Flanders presented their work on interdisciplinary education, in research paper sessions, practice paper sessions and

workshops. The abstracts of the workshops and papers can be found on the NIE conference website, as well as a photo impression of the day. 4TU.CEE is via Perry den Brok (WUR) also involved in the scientific board of an upcoming international conference on interdisciplinary education and research: the Association for Interdisciplinary Studies conference in Amsterdam (2019).

Boundary crossing

In 2018, WUR obtained the prestigious NWO Comenius Leadership Grant for a proposal on 'Boundary crossing as modus operandi at WUR'. The grant proposal was submitted by the dean of education, together with researchers from 4TU.CEE (den Brok), other colleagues at the Education and Learning Sciences group at WUR, and directors from 4 different programmes. In the study, over a 3-year period a framework, learning lines, tools and curriculum interventions will be developed in order to establish learning lines for boundary crossing. Boundary crossing is regarded as the skill to work together with others from different disciplines, cultures or practices/contexts (such as companies or societal institutions). The project is currently well under way, and has already resulted in a rubric to assess boundary crossing in different courses within a learning line.

4. Emerging technologies

4TU.CEE explored virtual labs and virtual reality systems as a means to acquire 'hands on' engineering skills. We explored which new technologies can contribute to enhanced learning. Specific attention was paid to a Pedagogical Framework for VR in education, virtual labs and blended learning. In addition, research was conducted on blended education and learning with digital resources during courses.

Explorative research into emerging technologies

Universities play an important role, preparing students for a labour market that is undeniably moving towards the use of new emerging technologies. These technologies though are recognised only to a very limited extend in tertiary education. Therefore, 4TU.CEE initiated an explorative research into emerging technologies in 2015-2017: 'Emerging technologies; do we need them and can we make them work'. The main aim of this research was to explore the current state of affairs in emerging technologies and develop insight into the perceived values of emerging technologies for higher engineering education. The report shows that to be able to deal with the challenges and to enhance the opportunities, education needs to develop a pro-active role. The researchers recommend stimulating the use of emerging technologies in higher engineering education by demonstrating their relevance.

VR Pilot studies

More in-depth insight was gained on the relevance of virtual reality for education in several pilot studies in Delft. One of the pilot studies focused on practicing presentation techniques with a virtual reality app or the ocular rift. Results were reported at the CDIO conference in 2017, the SEFI conferences in 2017 and 2018, the NACV conference 2018 and the TU/e education day. Another pilot focuses on embedding a virtual tour in education as addition to or replacing a field trip. Results were discussed at the CDIO 2018, TU/e Education day, VR-day in Delft and will also be presented at the Educon 2019 Conference. A "how to" factsheet is available on the 4TU.CEE website.

"Designing such a tour is still a relatively unexplored field of study. This pilot will provide us insight in formulating proper design requirements for a straightforward decision process for future virtual tours that contribute to enhancing student learning"

Researcher Danielle Ceulemans

Virtual Reality event

On October 5 in 2017 some 60 lecturers and educational support staff gathered in Utrecht to find out what Virtual Reality and Augmented Reality have to offer to education. Pierre Dillenbourg, Professor of Learning Technologies at EPFL, took us on a trip through the world of virtual and augmented reality and explained when it can be useful for education purposes. Max Louwerse, Professor of Cognitive Psychology and Artificial Intelligence at Tilburg University told about his experiences with the mixed reality lab in

Tilburg. The general feeling is that VR and AR should only be used in education when it contributes to the learning experience of students. Read more about the event in the blog of Aldert Kamp.

First year students' use of (digital) resources in mathematics education

With a plethora of (digital) resources available to first year engineering students studying mathematics, it becomes increasingly important to understand which resources are preferably (and beneficially) used by students from the ones on offer, and how they orchestrate them for their study of mathematics. At TU/e, a study was conducted involving a survey of close to 2.000 Calculus students. A mixed-method case study was used within Calculus and (smaller) Linear Algebra courses, to find out how engineering students study mathematics in their first year at TU/e. The study shows that it is not sufficient to provide an abundance of curriculum resources, may they be digital, traditional text or human resources, but that serious consideration should be given to how students might work with these resources, in order to orchestrate them into their preferred actual student study paths. In addition, it is advisable to help, perhaps even to educate students how to learn, that is how to develop such study paths, and these might be different from one subject to another (even from one mathematics course to another). Two conference papers have been published on this topic and an end report is in the making.

"For our study we have got a rather large Whatsapp group in which most of the first year students are participating. Nice thing about that is if you get stuck on a question or if you're unsure about something, you can post in the group. Even at four in the morning. If you post it there, there will be someone awake to answer your question. It's like the fastest customer service I've ever experienced."

First year student

Blended education

The 4TU are transforming their programme and course designs in order to make them more modern flexible, by incorporating a variety of blended solutions, involving video lectures, digital discussion platforms, on-line assessment, and so on. In 2017, WUR started research focusing on optimised blended education design. Under the WUR course innovations programme, several courses were granted funding for different blended solutions. These projects are used to gather data and experience, for example on the different interventions implemented with ICT and the results of these in terms of course satisfaction and other outcomes. The results, that show interesting differences between different courses and have resulted in a blended education model, so far were published in two publications and presented at the SEFI and CDIO conferences, and at a meeting of the Euro league universities for Life Sciences as well as in internal meetings with staff and teachers. Three more (journal) publications and presentations are in the pipeline for 2019 – 2021.

The UT started several projects to blend education. The ITC faculty started a Living Textbook. The project aims to create a different type of textbook, suitable to be used in modern blended learning and distance education settings. The textbook provides a better overview of the relationships between the concepts that are explained in the textbook by using a visual overlay, a concept map, connected to the

digital book in a Wiki environment. This concept map should help students getting a better grip on course materials. In 2019 the project continues to explore learning analytics and more personalised learning paths.

The UT started a pilot with blended labwork in 2018. Research was conducted with a digital solution to enhance the preparation and execution of labwork. The project aimed to improve preparation done by students and to give them a better overview of the entire lab experiment. The UT aims to present the results at the SEFI2019 conference.
In the ERASMUS+ CEPHEI project (Cooperative E-learning Platform for Higher Education in Industrial Innovation) 4TU.CEE members of the UT work together to build a community of digital learners in university and industry. The project aims to develop a cooperative e-learning platform for industrial innovation. The universities LUT (Finland), KTH (Sweden), MEF (Turkey) and UT will share their knowledge and expertise with respect to e-learning.

Digital testing in mathematics

Digital testing in mathematics is being implemented in collaboration with 4TU.AMI (mathematics colleagues). 4TU.CEE has supported evaluation of different aspects such as security when students bring their own laptop. This was checked by computer science students with a clear outcome: not secure. A project team then designed and evaluated how calculus could be tested digitally at the University of Twente, this time using chromebooks, finding a nice balance between high quality digital items (66%) and written items (34%). New implementations were then implemented for linear algebra and other topics. Results were presented at the UT education day 2017 and the 4TU mathematics meeting in Wageningen (2018). Harry Aarts used this project to write his SUTQ (SKO) report whereas Alisa Lochner used her master thesis to contribute to this project from the Educational Science perspective.

5. Engineering Education for all

Since student activity is key to learning effectiveness, the question of activating large and diverse student audiences is very relevant for education. Research shows that this can be enhanced by combining a variety of teaching methods. However, this can become a challenge in large-scale lectures, which will become increasingly common with the growing international student population. Engineering classes are subject to specific challenges as engineering students need to gain hands-on experience in labs that are not suited for large groups.

Interim assessment in large classes

In 2012, TU/e launched the Bachelor College reform. As part of this reform, interim testing was introduced for (almost) all bachelor courses. Courses were obligated to provide interim assessments during the course, such as exams or assignments that counted for at least 30% of the final grade. These interim tests would provide early feedback to students about their academic progress and encourage them to engage with their learning at an early stage in each course, and were expected to provide immediate benefits to students' learning achievements in courses, as well as teach them 'healthy' study habits in the long run (i.e. not always cramming at the last possible moment). Whether this approach works well and how interim assessments can be implemented effectively in large classes is the topic of the PhD research of Bram Vaessen that is being carried out for 4TU.CEE (in the research output, a published article can be found). The dissertation is expected in the beginning of 2020.

"The results so far showed that the short term goals of motivating students to study regularly can be achieved with regular interim assessments."

Bram Vaessen

Intercultural skills

Both students and teaching staff will need cross-cultural skills for their future career, given the increasing diverse student population and international focus and aims of programmes. A survey was held amongst the programme directors of UT and WUR in 2017. This survey, with 23 respondents, showed that 61% of programmes had a substantial amount of international students, up to more than 70% of their influx. The results also indicated the need for workshops for staff and students and a toolbox with materials, good practices and literature on the topic internationalisation. Since then, a variety of workshops has been developed and given by Marijke van Oppen (Intercultural trainer at WUR) and external trainers from November 2017 to December 2018. Topics involved supporting international students, inclusiveness for better study results, from emotional to cultural intelligence, and culturally appropriate and effective feedback. Each workshop

was attended by some 15 participants from 4TU at UT and WUR. The groups consisted of teachers, study advisors and student counsellors who highly appreciated the workshops.

> *"I liked the course design; alternating theory and group work"*
>
> Participant workshop supporting international students

The workshops will be repeated in 2019. Besides the workshops at the UT several educational programmes received specific support on dealing with intercultural challenges. In addition, a toolbox with materials, good practices and literature on internationalisation has been developed. It is based on an inventory of literature, websites, workshops and training materials from WUR and UT. The toolbox will become available online in spring 2019.

6. Teaching excellence

Improving the balance between research and education in career paths is one of the goals of this topic, of course in relation to the strategy of each university of technology. 4TU.CEE worked together with a project group of international universities in a pilot to explore how the University Teaching Framework created by Ruth Graham can contribute to portability of professional development across universities in the Netherlands and abroad. Another large project was the implementation and supervision of the Senior University Teaching Qualification at Twente University.

Teaching excellence via the Senior University Teaching Qualification (SUTQ)

Within the theme of teaching excellence many short developed courses and activities for lectures have been supported and initiated by 4TU.CEE in the last years (for example: learning spaces tour, OLIN college workshop). The activities helped in the further development of teaching excellence at the 4TU. At TU/e a small cohort of university teachers participated in the pilot of AUTIQ (Advanced University Teaching Innovation Qualification). In these AUTIQ projects engineering teachers design and evaluate their innovative engineering education strategies, typically linked to the university's education strategy. A mid-term evaluation has shown that one of the crucial elements for teachers in engineering education is the support of an experienced coach, who has knowledge of engineering education research.

One of the larger supported projects is the Senior University Teaching Qualification (SUTQ) at the University of Twente. In the last 2 years, 2 cohorts of lecturers have enrolled in the SUTQ. More than 20 lecturers passed the SUTQ. The SUTQ is based on a Scholarly approach of Teaching and Learning, the so called SoTL approach. This means that teachers are regarded as researchers and designers in their own field of expertise. In the SUTQ, participants transfer their design and research competencies to the domain of education. There was a large variety in the topics of the lecturers, ranging from innovations on hybrid testing, student centred teaching, serious gaming, wicked problems, and so on. Results were reported in a brochure. The final results also include more than 20 new innovations, that have been uploaded on the 4TU.CEE innovation map and many scientific contributions at (international) conferences.

"I believed that the very honest and useful feedback that I acquired through the various questionnaires that students filled in helped me become a better teacher, because they forced me to critically reflect on my own way of implementing student centered learning"

Thomas Groen, from first SUTQ brochure

"It was an achievement for me that I was able to conduct research about my own education and could generate some interesting findings written up in a scientific publication"

Andreas Hartmann, from first SUTQ brochure

Teaching Excellence: Career Framework

In a Royal Academy of Engineering collaboration with 15 international research oriented universities a teaching career framework was developed by Ruth Graham. This framework was well received at the VSNU Education Day in Wageningen, and has now been adopted in the Netherlands by many universities, VSNU, NRO and OCW. The framework supports improved appreciation of educational achievements. Staff and student feedback from pilots in two Twente faculties have fed into the last version of the framework, which is available now beyond the engineering community. In the next phase 4TU.CEE has committed itself to an international Teaching Culture Survey. Through this survey academic staff can indicate the state of affairs with respect to the appreciation of excellent teaching and career opportunities. First baseline outcomes are expected in May 2019 with further surveys planned for 2021 and 2023 aiming to measure progress at the 4 TUs with respect to the first outcomes and with the option to compare with an international benchmark. In addition, 4TU.CEE commissioned a roadmap study in which Ruth Graham will outline how other universities have achieved new ways of working and what pitfalls should be avoided.

Appendix 1: Impact (June 2016 – December 2018)

4TU.CEE events		
Onboarding day Virtual & Augmented Reality 5 October 2017 60 participants	**Workshop 'Compose the engineer of the future Dutch Design Week'** 26 October 2017 20 participants	**NIE conference TU/e** 30 January 2018 150 participants
The future of engineering education with MIT TU/e 17 May 2018 80 participants	**Workshop Interdisciplinary education Olin College** TU/e 26 November 2018 40 participants	
TU Events		
TEM Seminar at UT 31-05-2016 26 participants	**Entrepreneurial thinking tour -Donald Carpenter and Andrew Gerhart at TUD-TU/e-UT** 1-3 June 2016 15 participants	**Teaching trick tour Kristina Edström at TUD-TU/e-UT** 4-6 October 2016 75 participants
Workshops: Exploring Innovation and Innovative Digital Questioning at TUD 1 February 2017 35 participants	**Workshop Gamification by Alexandru Iosup at TU/e** 3 February 2017 40 participants	**Team Based Learning workshop at UT** 13 February & 28 November 2017 35 and 20 participants
Workshop Interdisciplinary teaching and learning at TUD 15 June 2017 30 participants	**Workshop Teacher coaching at TU/e** 3 July 2017 15 participants	**Teaching Trick workshop by Kristina Edström at WUR** 30 August 2017 25 Participants

TU Events		
UT Education day 19 October 2017 120 participants	**TU/e Innovation days** 5 October 2016 31 January 2018 21 November 2018 100 participants per event	**Teacher day WUR** 12 December 2017 11 December 2018 120 participants
Workshop compose the engineer of the future at TUD 7 November/ 20 December 2017 30 participants	**Colloquium Professional development for Higher Education Teaching staff at UT** 16 April 2018 35 Participants	**Workshop working with change agents at TUD** 18 April 10 participants
Lecture activating large classes 18 April at TUD 40 participants + live stream 10 participants	**Workshop Supporting international students at WUR** 9 May 2018 19 participants	**Workshop How to beat procrastination at WUR** 15 June 2018 14 participants
Workshop Inclusiveness at WUR 18 September 2018 13 participants	**Workshop From emotional to cultural intelligence** 21 September 2018 9 participants	**Workshop Rewarding Teaching Excellence: Next Steps (Ruth Graham) at UT** 52 participants
Lecture on Future of engineering education at UT 28 November 2018 140 participants	**Workshop Conducting educational design research (Reeves/McKenney) at UT** 28 participants	**Workshop Culturally appropriate feedback at WUR** 14 December 2018 13 participants

Activity	Views	Receivers
4TU.CEE Blogs: 14 (as of January 2017)	Varies per blog from 250- 5000 views	Not specified
4TU.CEE Newsletters: 10 (as of January 2017)	Not specified	TUD: approx. 1500 TU/e: approx. 1100 UT: approx. 200 and dispersion through employee portal WUR: dispersion through employee portal
Hits / visitors of the 4TU.CEE website	Number of viewed pages: 13.544 (2017) 20.309 (2018)	3574 users with 5742 sessions (2017) 5824 users with 8975 sessions (2018)[1] 15% returning visitors

Activity	Projects	People involved
Innovation map	179 projects per Sept. 2018	242 per Sept. 2018

[1] Visitors on the site of 4TU.CEE as a whole.

Appendix 2: Overview 4TU.CEE output (June 2016 – December 2018)

Publications	Internal (research) reports
	University of Twente (2018). Senior university teaching qualification: University of Twente projects of 2017-2018.
	Aarts, A. F. M., Posthuma, A. S., Slotman, K. M. J., & Kosters, A. (2017). Is safe testing possible on a chromebook?
	Kamp, A. (2016). Engineering Education in the Rapidly Changing World: Rethinking the Vision for Higher engineering Education (2nd revised edition). Delft: TU Delft, Faculty of Aerospace Engineering. https://repository.tudelft.nl/islandora/object/uuid:ae3b30e3-5380-4a07-afb5-dafd30b7b433?collection=research
	Scientific articles or book contributions
	Bron, R., Endedijk, M. D., van Veelen, R., & Veldkamp, B. P. (2018). The Joint Influence of Intra- and Inter-Team Learning Processes on Team Performance: A Constructive or Destructive Combination? Vocations and learning, 11(3), 449-474. https://doi.org/10.1007/s12186-018-9197-z
	Gast, I., Schildkamp, K. & van der Veen, J. T. (2017). Team-Based Professional Development Interventions in Higher Education: A Systematic Review. Review of educational research, 87(4), 736-767. https://doi.org/10.3102/0034654317704306
	Klaassen, R. (2018). Interdisciplinary education: a case study. Published online in: European Journal of Engineering Education 43:6, 842-859. https://doi.org/10.1080/03043797.2018.1442417
	MacLeod, M., & Nagatsu, M. (2018). What does interdisciplinarity look like in practice: Mapping interdisciplinarity and its limits in the environmental sciences. Studies in History and Philosophy of Science, Part A, 67, 74-84. https://doi.org/10.1016/j.shpsa.2018.01.001
	MacLeod, M. A. J. (2018). What makes interdisciplinarity difficult? Some consequences of domain specificity in interdisciplinary practice. Synthese, 195(2), 697. https://doi.org/10.1007/s11229-016-1236-4

Publications

Scientific articles or book contributions

Meulenbroeks, R.F.G., Veen, J.T. van der, & Eijkelhof, H.M.C. (2018). Helping engineers become good physics teachers. Physics Today.
DOI:10.1063/PT.6.5.20180713a

Van Diggelen, M. R., & Morgan, C. M. (2017). Studying teacher coaching: how was it intended, implemented and perceived? Eindhoven: Technische Universiteit Eindhoven.

Conference contributions

Boer, A. de, & Gommer, E. M. (2018). Aircraft engineering, an interdisciplinary minor module. In C. Bean, J. Bennedsen, K. Edström, R. Hugo, J. Röslof, R. Songer, & T. Yamamoto (eds), The 14th International CDIO Conference: Proceedings – Full Papers. 14th International CDIO Conference, Japan

Bombaerts, G.J.T, Doulougeri, K.I., Spahn, A., Nieveen, N.M. & Pepin, B.E.U. 2018. The course structure dilemma: Striving for Engineering students' motivation and deep learning in an ethics and history course. In Clark, R., Munkebo Hussmann P., Järvinen H-M., Murphy, M., & Etchells Vigild, M.(eds), Proceedings of the 46th SEFI Annual Conference 2018 : Creativity, Innovation and Entrepreneurship for Engineering Education Excellence (pp. 79-87). SEFI 2018, 46th SEFI Annual Conference 2018, Copenhagen, Denmark.

Bron, R., Endedijk, M. D., & Veldkamp, B. P. (2017). Exploring higher education teacher team learning using text mining analysis. Paper presented at 17th Biennial Conference of the European Association for Research in Learning and Instruction (EARLI) 2017, Tampere, Finland.

Cabo, A. & Klaassen, R. (2018), Active learning in redesigning mathematics courses for engineering students. In C. Bean, J. Bennedsen, K. Edström, R. Hugo, J. Röslof, R Songer & T Yamamoto (eds), The 14th International CDIO Conference: Proceedings – Full Papers (704-715). CDIO, 14th International CDIO Conference, Kanazawa, Japan.

Edelbro, C., Hulthén, E., Clausen, E., Tanner, D., Herrera Herbert, J., Jonsson, K., Bealieu, S., Kamp, A. & Försth, M. (2017). European initiative on CDIO in raw material programmes. In Proceedings of 13th International CDIO Conference 2017. 13th international CDIO Conference 2017, Calgary, Canada, 19/06/17.

Gast. I., Schildkamp, K., Veen, J.T. van der, McKenney S.E. & J.W. Luyten (2017). Teacher attitudes toward team-based educational innovation in higher education: Influencing factors at individual, team and organisational levels. Onderwijs Researchdagen, 28-30 June, Antwerpen.

Geveling, B. (2018). Team-based Learning in a mathematics course. Øresundsdagen, 31 October, DTU, Lyngby, Denmark

Publications	Conference contributions
	Gomez Puente, S. M., Exarchakos, G., & Raz, O. (2017). Connecting the world with internet of things. In 45th SEFI Conference, 18-21 September 2017, Azores, Portugal (pp. 1-9).
	Gomez Puente, S.M., Kroesen, G.M.W. & Kunnen, R.P.J. (2018). Enhancing interdisciplinary hands-on education in the field of magnetic levitation mobility and signals analysis and control. In R. Clark, P. Munkebo Hussmann, H-M. Järvinen, M. Murphy, & M. Etchells Vigild (eds), Proceedings of the 46th SEFI Annual Conference 2018 : Creativity, Innovation and Entrepreneurship for Engineering Education Excellence. SEFI 2018: Creativity, innovation and entrepreneurship. Copenhagen, Denmark.
	Gommer, E.M. (2017). Self-Directed Learning in a Research Course for Mechanical Engineers. 13th International CDIO Conference in Calgary, Canada.
	Klaassen, R., Rouwenhorst, C., Brans, C.H.T.A. (2018). Space Driven Educational Innovation. In R. Clark, P. Munkebo Hussmann, H-M. Järvinen, M. Murphy, & M. Etchells Vigild (eds), Proceedings of the 46th SEFI Annual Conference 2018 : Creativity, Innovation and Entrepreneurship for Engineering Education Excellence. SEFI 2018: Creativity, innovation and entrepreneurship. Copenhagen, Denmark.
	Klaassen, R., Ceulemans, D. & de Vries, P. (2018). The Applicability of Feedback of Virtual Speech app metrics in a Presentation Technique Course. In R. Clark, P. Munkebo Hussmann, H-M. Järvinen, M. Murphy, & M. Etchells Vigild (eds), Proceedings of the 46th SEFI Annual Conference 2018 : Creativity, Innovation and Entrepreneurship for Engineering Education Excellence. SEFI 2018: Creativity, innovation and entrepreneurship. Copenhagen, Denmark.
	Klaassen, R., van Dijk, M., Hoope, R., Ceulemans, D., Kamp, A., Jacobs, M. & van der Sanden, M. (2018). A design-based vision on future roles in engineering. In C. Bean, J. Bennedsen, K. Edström, R. Hugo, J. Röslof, R Songer & T Yamamoto (eds), The 14th International CDIO Conference: Proceedings – Full Papers (pp. 882-894). 14th International CDIO Conference, Kanazawa, Japan.
	Klaassen, R., de Vries, P. & Kamp, A. (2017). Emerging technologies in engineering education: can we make it work? In Proceedings of 13th International CDIO Conference 2017 (pp. 1-12). 13th international CDIO Conference 2017, Calgary, Canada, 19/06/17.
	Klaassen, R., de Vries, P., Ioannides, M.G. & Papazis, S. (2017). Tipping your toe in the 'Emerging Technologies' pond from an educational point of view. In Proceedings of the 45th SEFI Annual Conference 2017: Education Excellence for Sustainability, 18-21 Sept. 2017, Azores, Portugal. 45th SEFI Annual Conference, Angra do Heroísmo, Portugal.
	Kock, Z.-J., & Pepin, B. (2018). Student use of resources in Calculus and Linear Algebra. In V. Durand-Guerrier, R. Hochmuth, S. Goodchild & N.M Hogstad (Eds.), Proceedings of the Second Conference of the International Network for Didactic Research in University Mathematics (INDRUM 2018, 5-7 April 2018) (pp. 347-356). Kristiansand, Norway: University of Agder and INDRUM.

Publications	Conference contributions
	Kock, Z.-J., & Pepin, B. (2018). First year engineering students' selection and use of resources to learn mathematics. Poster presented at the ERME Topic Conference Mathematics Education in the Digital Age, Copenhagen, Denmark.
	Lochner, A. (2018). Framework for Undergraduate Mathematical Digital Testing. 4TU.AMI InterTU-Studiedag, 29 June, Wageningen.
	Maynard, N, Rooij, R. (2018). Workshop Embedding, Teaching and Assessing Teamwork Skills- How hard can it be. 14th International CDIO Conference, Kanazawa, Japan
	Meikleham, A., Hugo, R., Kamp, A. & Malmqvist, J. (2018). Visualizing 17 years of CDIO influence via bibliometric data analysis. In C. Bean, J. Bennedsen, K. Edström, R. Hugo, J. Röslof, R. Songer & T. Yamamoto (eds), The 14th International CDIO Conference: Proceedings – Full Papers. CDIO, pp. 53-72, 14th International CDIO Conference, Kanazawa, Japan.
	Oosterhuis, J., & Sjerps M.H.M.E. (2018). Teaching Excellence: op waarde geschat! Workshop, VSNU Onderwijsfestival, 24 May 2018, Wageningen
	Oude Alink, C., Schretlen, J., Stobbelaar, T., Thomas, T. (2018). Deep or surface approaches to studying, which is applied? Comparing study skills of first year engineering. In R. Clark, P. Munkebo Hussmann, H-M. Järvinen, M. Murphy, & M. Etchells Vigild (eds), Proceedings of the 46th SEFI Annual Conference 2018 : Creativity, Innovation and Entrepreneurship for Engineering Education Excellence. SEFI 2018: Creativity, innovation and entrepreneurship. Copenhagen, Denmark.
	Pepin, B., & Kock, Z.-J. (2018). First year engineering students' use and orchestration of resources to develop actual student learning paths: The cases of Calculus and Linear Algebra. In R. Clark, P.M. Hussman, H.-M. Jarvinen, M. Murphy & M.E. Vigild (Eds.), Proceedings of the 46th SEFI Annual Conference 2018 : Creativity, Innovation and Entrepreneurship for Engineering Education Excellence. SEFI 2018: Creativity, innovation and entrepreneurship (pp. 356-364). Copenhagen, Denmark: Technical University of Denmark and SEFI.
	Polderman, J.W. (2018). Blended Learning in Calculus & Linear Algebra and Digital Testing in Mathematics. Workshop ICAB2018, 29 November, UT, Enschede
	Smulders, F., Kamp, A. & Fortin, C. (2018). The CDIO framework and new perspectives on technological innovation. In C. Bean, J. Bennedsen, K. Edström, R. Hugo, J. Röslof, R. Songer & T. Yamamoto (eds), The 14th International CDIO Conference: Proceedings – Full Paper (pp. 40-52). 14th International CDIO Conference, Kanazawa, Japan.
	van den Bogaard, M.E.D. & Klaassen, R. (2017). The effects of curriculum overhaul: investigating the students' experience. In Proceedings of 7th Biannual Research in Engineering Education Symposium, REES 2017., 157, Universidad de los andes, Bogota Colombia, Research in Engineering Education Symposium 2017, Bogota, Colombia.

Publications	Conference contributions
	van Berkum, M., & Diederen, J. (2018). Balancing online and face-to-face learning activities. Euro League for Life Sciences LLS General Assembly and Forum 2018. Wageningen.
	van Puffelen, E.A.M. (2017). Designing blended engineering courses. Proceedings of the 45th SEFI Annual Conference 2017: Education Excellence for Sustainability, 18-21 Sept. 2017, Azores, Portugal
	van Puffelen, E.A.M., van Berkum, M.,& Diederen, J. (2018). Balancing online and face-to-face teaching and learning activities. 14th International CDIO Conference. Kanazawa, Japan.
	Veen, J.T. van der, Pepin, B., Fortin, C. & C. Rouwenhorst (2018). Towards a Career Development Framework for Teaching. Workshop. CDIO Regional Meeting, 17-19 January, Skoltech, Moscow.
	Veen, J.T. van der, & Hahnen-Florijn, M.E. & Poortman, C. & Schildkamp, K. & Mckenney, S. (2017). Senior university teaching qualification via engineering education research and design. Proceedings of the 45th SEFI Annual Conference 2017: Education Excellence for Sustainability, 18-21 Sept. 2017, Azores, Portugal.
	Veen, J.T. van der & Meulenbroeks, R. & Eijkelhof, H.M.C. (2018). Engineers in the Physics Classroom: Helping engineers become physics teachers. Proceedings of the 46th SEFI Annual Conference 2018: Creativity, Innovation and Entrepreneurship for Engineering Education Excellence. Copenhagen
	Vreman-de Olde, G.C. (2018). Shoot for the Moon. Implementing the Personal Development Plan (PDP) and Mentoring in the Honours Science Track.
	Exchange Market, 8 October, Hanzehogeschool, Groningen.
	Site visits at other international engineering universities
	Study trips by 4TU.CEE board: - EPFL Lausanne and ETH Zurich, Switzerland 13 & 14 March 2017 - Leuven, Belgium 26 & 27 March 2018 Related interview at: https://set.kuleuven.be/LESEC/vision2/vision13 (p6/7)

Network	Site visits by international scholars
	- Donald Carpenter and Andrew Gerhart. Lawrence Technical University. 1-3 June 2016. Entrepreneurial thinking in engineering education. - Kristina Edström & Jakob Kuttenkeuler. KTH. 4-6 October 2016. Teaching tricks. - Kristina Edström. KTH. 30 August 2017. Teaching tricks. - Pierre Dillenbourg. EPFL Zürich. 5 October at VR event 2017. Using virtual reality in education. - Maria Knutson Wedel. Chalmers University. Interplay of research and education. - Pedro de Bruyckere. 19 October 2017 at Education day Twente. Urban myths about learning and education. - Monika Rummler. TU Berlin. 17&18 April 2018. Activating large classes & working with change agents. - Dr. Amitava Babi Mitra. MIT. 17 May 2018. Engineering education of the future. - Eugenio Bravo, Mechanical Engineering, Universidad de Chile. 27, 28 June, 2018 - Prof. Siddhartan Govindasamy and Prof. John Geddes. Olin College. 26 & 27 November 2018. Interdisciplinary education. - Ruth Graham. Royal Academy of Engineering Education. 28 November 2018. Future of Engineering Education. -Thomas Reeves. University of Georgia, Athens (US). 12 December 2018. Conducting education design research.

Appendix 3: Overview 4TU.CEE PhD researchers & master theses

PhD Researcher	Subject	Supervision	End date
Inken Gast (UT)	Team-based professional development	Promotores: dr. K. Schildkamp, prof.dr. S. McKenney; daily supervisor: dr. J. van der Veen	Obtained doctorate on 13 December 2018
Rike Bron (UT)	Teacher teams and team learning processes	Promotor: prof.dr.ir. B. Veldkamp; daily supervisor: dr. M. Endedijk	Fall 2019
Bram Vaessen (TU/e)	Intermediate assessment in higher engineering education	Promotores: Prof. dr. P. den Brok & prof. dr. L. Lemmens; daily supervisor: dr. A. van den Beemt	Spring 2020
Marta Gavioli (TUD)	A lab-in a box for structural analysis education	Promotores: prof. ir. C. Bisagni & prof. dr. P. den Brok; daily supervisor: R. Klaassen	Spring 2021
Ljubov van Beek (TUD)	Evaluative Judgement and self-regulated learning in higher education	Promotores: prof. dr. M.J. de Vries, prof. dr. J.W. Strijbos (RUG); co-promotor: dr. D. Kostons (RUG); co-promotor/daily supervisor: dr. M.E.D. van den Bogaard	Winter 2021
Kostis Karanasios (TU/e)	Designing authentic learning environments to educate the future engineer	Promotor: prof. dr. J.D.H.M. Vermunt; daily supervisor: dr. G. Bombaerts	2022
Priyanka Pereira (UT)	Student driven learning: self and peer regulation	Promotores: dr. K. Schildkamp, prof. dr.ir. B. Veldkamp	2022
Marloes Vreekamp (WUR)	Teacher learning during the University Teaching Qualification trajectory.	Promotor: prof. dr. P. den Brok; daily supervisors: dr. P. Runhaar & dr. J. Gulikers	2023
Master Student	**Subject**	**Supervisor**	**End date**
Grace Nguyen (UT)	Classroom of the Future	dr. J. van der Veen	December 2018
Nikos Basbas (UT)	Advanced professional development for university teachers	dr. K. Schildkamp	January 2019
Alisa Lochner (UT)	Digital testing in mathematics.	dr. J. van der Veen	January 2019

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