4TU.Centre for Engineering Education

Strategic plan 2022-2025

July 2021

Management summary

During the past years, the 4TU.Centre for Engineering Education (4TU.CEE) has established itself as a Centre with expertise on educational innovations in engineering education. Both teachers from the four universities and (inter)national partners approach 4TU.CEE to collaborate, either in the implementation of innovations or in their evaluation and dissemination of results. 4TU.CEE has been involved in the organisation of conferences and workshops, such as the 2020 SEFI conference and the 2018 international CDIO meeting. 4TU.CEE has been successful in obtaining several research grants and has become a national leading example with its work in career frameworks and teaching excellence based on a long-standing collaboration with Ruth Graham. The 4TU.CEE innovation map has been recognized as a good practice of knowledge infrastructure. Over the years, practical tools as well as scientific publications have been produced. 4TU.CEE projects topics varied widely from teaching excellence to interdisciplinary engineering education, and from future engineering roles to engineering educational ecosystems. The Covid-19 pandemic brought all kinds of challenges for lecturers and students, but also gave a boost to online engineering education, research and reflection on this topic.

For the upcoming years, 4TU.CEE will focus on 5 topics:

1. Educating for responsible engineering/the ethical and responsible engineer: Ethical and sustainable behaviour competences and mind-set, boundary crossing; awareness raising for ethics and sustainability; motivating engineers for dealing with moral or ethical issues and questions; addressing engineering and technology specific topics with moral questions such as social media, AI, robotics, etc.; collaboration with 4TU.Ethics.

2. Entrepreneurial learning/academic entrepreneurship: Entrepreneurial context of engineering; entrepreneurial mind-set/attitude and entrepreneurial or innovation skills, such as creativity, opportunity seeking, creating value, risk taking, leadership and self)management skills; entrepreneurial skills embedding, teaching and assessment.

3. Challenge-Based Learning: New forms of challenge-based learning (CBL) or challenge-based education; Hubs, living labs, innovation spaces or more course based forms of learning via challenges; linking extracurricular activities to the curriculum; identification and variation in forms of CBL, its characteristics, typical learning activities, processes and outcomes/effects, including assessment; inter- and transdisciplinary education, boundary crossing, the (potential) role of the university in supporting these activities, and the relation of the university with society.

4. <u>Teaching excellence in engineering education: Diversification of career pathways strategy (VSNU, KNAW, NWO, 4TU):</u> Work with international partners; establishing career development paths of teachers, establishing indicators of engineering teaching quality, forming teaching academies and investigating teacher learning during educational innovations that are either bottom-up or top-down; new roles of teachers as coaches and designers of blended learning.

5. <u>ICT enhanced education and the digitally literate engineer</u>: This topic consists of two subtopics: (a) ICT enhanced engineering education - Flexible and personal learning paths of learners, blended or online solutions for teaching and learning, especially for engineering specific activities such as lab education, excursions, collaboration in augmented or virtual reality, post Covid-19 hybrid education. (b) Digitally literate engineers: Digital literacy and information skills, using digital tools to design or test solutions, and digital collaboration; Industry 4.0, data security; the future role of computer science and mathematics; relevance of data security and privacy.

The first two topics: the ethical and responsible engineer, and entrepreneurial learning relate to the overarching theme of the engineer of the future. The third and fourth topics, challenge-based learning and teaching excellence in engineering education, fall within the second overarching theme of future engineering education. The fifth topic fits in both themes, partly focusing on the future engineer (the digitally literate engineer) and partly on future engineering education (ICT enhanced education).

Activities

4TU.CEE will continue to focus on a mixture of practical outcomes as well as scientific outcomes. In the upcoming years we expect several 4TU.CEE funded PhD and postdoc trajectories to be completed. Also, the Centre will aim for obtaining at least one major grant. 4TU.CEE will continue to organise and host workshops and invite international scholars to inspire teachers at the four universities, such as the recent 'challenge based learning' seminar series, that was organised during 2021.

Collaboration

4TU.CEE will continue to work at different levels. Some projects and activities will focus on teachers or single universities, but many activities will be conducted in collaboration between the four TUs. We will also further strengthen our national and international partnerships. For

example, 4TU.CEE has recently been involved in co-hosting the PRACTESE sessions, a series of colloquia in which PhD students in engineering and science education from the 4TUs, KU Leuven and the University of Melbourne present their work to each other. Collaboration within the 4TU network will be continued by engaging in joint projects around entrepreneurial learning, challenge based learning and teaching excellence, and in other themes. Local projects connect to staff from the other TUs who work on related topics or projects and investigate cases across multiple TUs.

In short, 4TU.CEE is eager to support the development of future engineering education and help in establishing an empirical knowledge base on innovation in engineering education. We look forward to doing so, together with you as our partners!

Sincerely,

photo: Dieuwertje Bravenboer

Prof. Perry den Brok, chair of 4TU.Centre for Engineering Education

Covid-19 measures in the classroom

Contents

Introduction

Looking back (2018-2021)

During the past period (2018-2021), 4TU.CEE matured in several ways. It established itself as a national and international expertise centre by organising various large meetings and conferences, such as the 2nd National conference on Interdisciplinary Education (Eindhoven, 2018), the international meeting for the CDIO (Conceive, Design, Implement, Operate) network (Delft, 2018) and the annual conference of the SEFI (European Society for Engineering Education) organisation (Twente, 2020). The innovation map was further expanded and now contains over 245 innovations. The 4TU.CEE webpages were visited almost 40,000 times. The Centre's workshops and seminars were well attended. Before Covid-19 hit, several international experts visited the universities and gave workshops: Monika Rummler (TU Berlin, activating large groups), Babi Mitra (MIT, future engineering education), Eetu Ekman Kaleevi (Aalto University, learning spaces), Eugenio Bravo (Universidad de Chile, mechanical engineering), Siddhartan Govindasami and John Geddes (Olin College, interdisciplinary engineering education) and Ruth Graham (Royal Academy of Engineering, future engineering education).

Research

4TU.CEE was successful in obtaining several research grants, such as NWO Comenius Leadership grants at WUR (boundary crossing as modus operandi), UT (interdisciplinary design modules) and TU/e (challenge-based learning). It was also granted an NWO (NRO) grant on teacher learning during innovations in higher education. During 2018-2021 the first 4TU.CEE funded PhD students finished their dissertations, such as Inken Gast (UT, teacher development teams) and Bram Vaessen (TU/e, student perceptions of assessment), while several other PhD students and postdocs started up their projects. Together with KU Leuven and the University of Melbourne, 4TU.CEE co-hosts the PRACTESE symposium, where PhD students present and exchange their projects on higher (engineering) education.

Forerunner

4TU.CEE became a national leading example with its work in career frameworks and teaching excellence based on a long-standing collaboration with Ruth Graham, as well as with its innovation map, which was recognized as a good practice of knowledge infrastructure. Aldert

Kamp (TUD) also wrote some influential position papers, for the CESAER (European associations of deans in engineering education) network for example and his farewell publication 'Navigating the landscape of higher engineering education'. Research on teacher and student learning during the Covid-19 period was presented in a keynote by 4TU.CEE chair Perry den Brok during a national conference for STEM educators.

4TU.CEE started and finished a host of innovation and research projects, and was involved in several innovative courses, such as the Joint Interdisciplinary Project (JIP, TUD), or new developments, such as education fellowships and the Senior University Teaching Qualification (UT). It also organised a series of workshops for TU educators, on intercultural education, learning spaces and challenge-based education, for example.


During the past strategic period (2018-2021), strategic topics of focus were: (1) educating engineers for the future, (2) interdisciplinary engineering education, (3) engineering educational ecosystems and (4) teaching excellence in university engineering education.

The impact of Covid-19

The Covid-19 pandemic brought all kinds of challenges for lecturers and students and gave a boost to online engineering education and research on this topic. At each TU, 4TU.CEE was involved in research monitoring the effects of the transition to online education on courses, teachers and students, both in terms of teaching and learning activities as well as in terms of well-being. Currently, the findings of these studies are being collected and will be published in a position paper. Interestingly, Covid-19 also brought to the fore the wider topic of resilience and well-being, which certainly will be investigated further in the upcoming years.

Personnel changes

During the past years, there were several changes in 4TU.CEE leadership. Dr. Jan van der Veen stepped down as UT leader of 4TU.CEE. His leadership was taken over by dr. Cindy Poortman. Ineke ten Dam stepped down as 4TU.CEE coordinator at UT and Chris Rouwenhorst returned in this position. At TU/e, dr. Antoine van den Beemt and dr. Alexander Schuler-Meyer who acted as temporary 4TU.CEE leaders at TU/e were succeeded by prof. Birgit Pepin. At TUD, ir. Aldert Kamp stepped down as 4TU.CEE leader, leaving the Centre with a nice visionary document 'Navigating the landscape of higher engineering education'. Prof. Marcus Specht and dr. Remon Rooij became new TUD leaders.
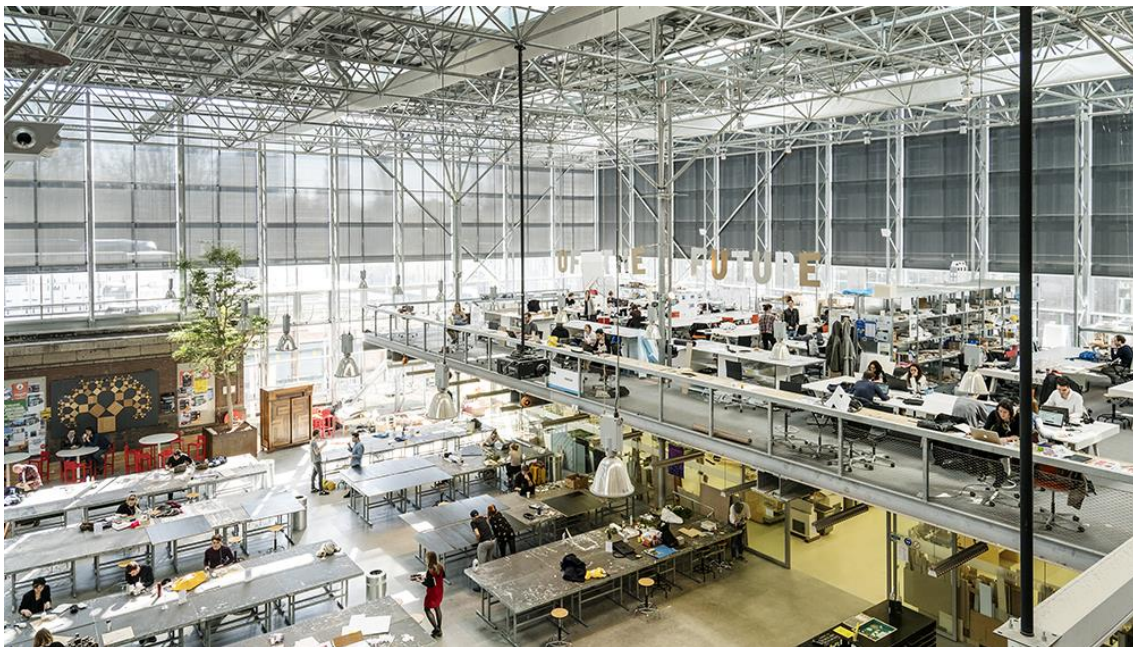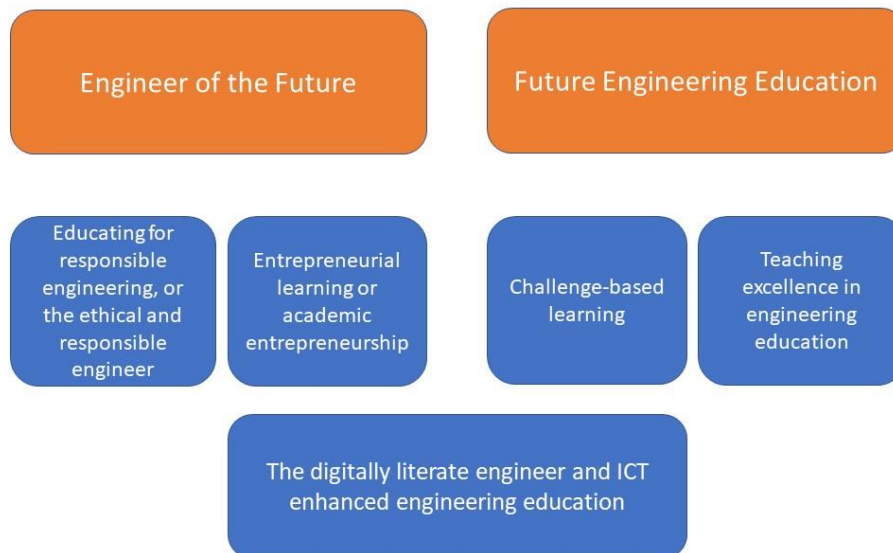
4TU.CEE strategy for 2022-2025

Strategic themes

The first point of departure for the 4TU.CEE strategy for 2022-2025 is formed by topics as proposed by 4TU.CEE, discussed with and approved by the 4TU. Education board. These topics comprise two overarching themes, namely Engineer of the Future and Future Engineering Education. Within the theme Engineer of the Future, three topics are distinguished: Entrepreneurial learning or academic entrepreneurship, Educating for responsible engineering or the ethical and responsible engineer, the digitally literate engineer. The theme Future Engineering Education is distinguished into Challenge-based learning, Teaching excellence in engineering education and ICT enhanced education. The ICT/digital topic is thus a combination of both Engineers of the Future and Future Engineering Education.

Two overarching themes and their topics for 2022-2025

The second starting point for the 4TU.CEE strategic plan forms the annual budget structure and budget size as it has been over the past strategic period (2018-2021), which was confirmed by the 4TU education board earlier.

Topics

The five topics in short:

1. <u>Educating for responsible engineering/the ethical and responsible engineer</u>: Ethical and sustainable behaviour competences and mind-set, boundary crossing; awareness raising for ethics and sustainability; motivating engineers for dealing with moral or ethical issues and questions; addressing engineering and technology specific topics with moral questions such as social media, AI, robotics, etc. ; collaboration with 4TU.Ethics.

2. <u>Entrepreneurial learning/academic entrepreneurship</u>: Entrepreneurial context of engineering; entrepreneurial mind-set/attitude and entrepreneurial or innovation skills, such as creativity, opportunity seeking, creating value, risk taking, leadership and (self)management skills; entrepreneurial skills embedding, teaching and, assessment.

3. <u>Challenge Based Learning: New forms of challenge-based learning (CBL) or challenge-based education</u>: Hubs, living labs, innovation spaces or more course based forms of learning via challenges; extracurricular activities; identification and variation in forms of CBL, its characteristics, typical learning activities, processes and outcomes/effects, including assessment; interdisciplinary education, boundary crossing, and the (potential) role of the university in supporting these activities.

4. <u>Teaching excellence in engineering education</u>: Diversification of career pathways strategy (VSNU, KNAW, NWO, 4TU); work with international partners; establishing career development paths of teachers, establishing indicators of engineering teaching quality, forming teaching academies and investigating teacher learning during educational innovations that are either bottom-up or top-down; new roles of teachers as coaches and designers of blended learning.

5. <u>ICT enhanced education and the digitally literate engineer</u>: Flexible and personal learning paths of learners, blended or online solutions for teaching and learning, especially for engineering specific activities such as lab education, excursions, collaboration in augmented or virtual reality, post Covid-19 hybrid education. Digital literacy and information skills, using digital tools to design or test solutions, and digital collaboration; Industry 4.0, data security; the future role of computer science and mathematics; relevance of data security and privacy.

The projects and activities described under the themes will focus at multiple levels: the level of individual teachers and/or their courses, the level of educational programmes, the level of the entire university, and even the level of national and international university networks. Different partners and stakeholders will be involved: teachers, support staff, management, companies or other external partners and students.

Strategy

At each university, support for the themes, topics and anticipated projects has been sought by having meetings with programme directors, deans (of education) and teachers in addition to surveys among staff. As such, we feel that the proposed strategic plan is well supported and grounded in the needs of those involved in innovation in engineering education.

In this section, we would like to highlight a few things in general, after which more detailed plans per university will be discussed. The first thing to highlight is the fact that several projects and topics of the past strategic plan will continue into the new strategic plan. This continuation mainly concerns some of the larger projects, especially involving PhD students, but also the topics Teaching excellence and Challenge-based learning, which were started in the past strategic period.

Second, the 4TUs will collaborate intensively in several topics, sometimes by bringing together findings of separate projects or initiatives, as is the case with the transition to online education during the Covid-19 crisis or with challenge-based learning. The 4TUs will also collaborate by initiating joint projects. In the upcoming strategic period, joint projects will be launched on Entrepreneurial learning and education and in Teaching excellence. In the latter topic, 4TU.CEE hosts a project leader on educational careers in engineering education, and all 4TU's participate in and collaborate with projects of Ruth Graham. Wherever possible, we open up our cases in projects for other 4TU partners to study or explore. In dissemination and presentations of results of projects, we will regularly bring together findings from projects at different locations, for example in joint policy papers or advise. Finally, we will organise joint professional development activities, such as recently the CBL webinars and Learning Spaces tour.

Third, we will further expand our international activities. Where prior strategic periods mainly focused on establishing 4TU.CEE locally and nationally, over the past years, we have become more active internationally by writing peer-reviewed articles in international journals, by organising large events or conferences, such as the CDIO conference (2018, Delft) and SEFI conference (2020, Twente), by starting up an international PhD symposium together with KU

Leuven and the University of Western Australia, and by participation in CESAER. We will continue our active participation in CESAER, SEFI and CDIO, our involvement in the international PhD symposium for engineering education, and our international publications in the upcoming strategic period. We also aim to organise at least one large conference or international meeting, and we strive to apply for a European or international grant/project. Our collaboration may well extend beyond Europe, as we have good contacts in Australia, China, Singapore and the US.

Fourth, research on ICT in engineering education will continue to remain an important topic. During the past strategic period, studies were started on the transition to online education during the Covid-19 period. The studies' findings are currently being merged into a white paper containing recommendations for higher engineering education. It is expected that all 4TU's will continue to experiment with new tools and will contemplate new blends of education; 4TU.CEE aims to support these developments, for example by investigating these experiments or via its support to teaching fellowships that often focus on similar topics. However, in the upcoming period the theme of ICT in engineering education will be further expanded by also looking how ICT shapes engineering itself, and how programmes may be able to better support their graduates in these developments.

Similar to our previous strategic period, we will continue to innovate and research via a portfolio of varied projects, ranging from providing support via small-scale projects of individual teachers or courses, to large-scale, more complex and long-term projects conducted by postdocs or PhD students. Projects thus vary between local and practice-based to more cross-university and fundamental. As indicated, next to starting projects via university funding, we also aim to be involved in and apply for grants. In the past period, 4TU.CEE has been successful in applying for NWO (NRO) grants, Comenius grants or has supported other staff in applying for SURF or innovation grants. We aim to contribute more to university policy and leadership by providing input in strategic discussions, writing policy papers, or organising inspiration sessions around topics; and by paying more attention to policy recommendations in projects next to recommendations for teachers or educational practitioners. Students will be involved in our projects as assistants, via lunch meetings or other sessions. We also aim to involve students more in our projects via theses or internships.

It should be noted that while all TU's focus on the new strategic themes, there are differences between the different 4TU.CEE locations, with some TU's investing more (or more prominently) in certain topics. These differences result from how the budget is assigned within a university (sometimes linked to or determined by university-wide innovation funds or IT programmes), prior obligations, and local interests and strengths. Finally, most universities are also involved in other university alliances, and where possible, this has been taken into account (for example, by preventing a double focus on the same topic). However, as indicated by our second highlight, the collaboration will exist and continue on each of the mentioned themes.
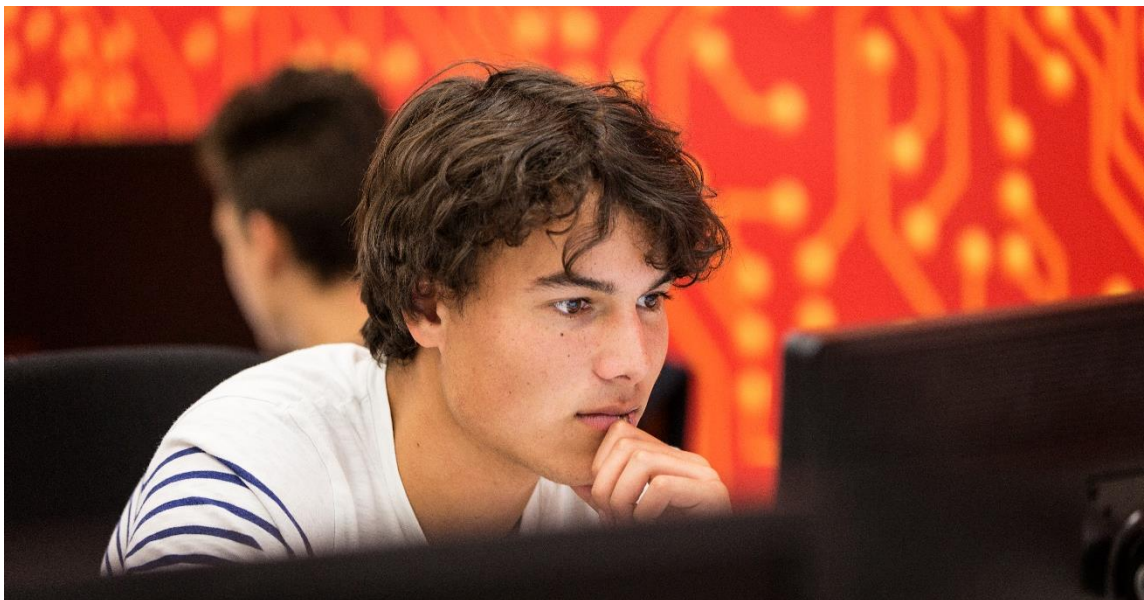
Strategic emphases per TU

TUD will have three main focus points: (1) Challenge-based education; (2) ICT-driven engineering and educational innovation and (3) Entrepreneurship and entrepreneurial thinking. The Challenge-based education (CBE) topic will focus on the implementation of reflective engineering and the future vision of the university in CBE, as well as staff development and analysis of trans/interdisciplinary learning. The topic ICT-driven engineering will address three levels of change; (1) Digitisation and virtualisation of scalable study support structures; (2) Open educational resources and shared curricular modules for future engineering education and (3) Hybrid collaboration technologies and didactical design for engineering education and collaborative learning. The topic Entrepreneurship will address the principles and implementation of entrepreneurial learning environments. Additionally, staff development for entrepreneurial pedagogies will be developed. Besides these three foci points the Ethics and Teacher excellence initiatives will be continued.

TU/e will continue to focus on ICT enhanced education and the post Covid-19 research by investing in relevant projects with Innovation Fund grants. Challenge-based Learning (CBL) is a central topic throughout TU/e. With three postdocs conducting research and several Innovation Fund granted projects, TU/e is contributing to research and the development of CBL. A joint exploration has started into what CBL has to offer for students, teachers and other stakeholders in our society, together with colleagues from TU/e innovation Space and different departments at TU/e. Teaching excellence has emerged as a TU/e wide focus topic. Beside participating in the international Teaching Excellence research of Ruth Graham, TU/e leads the NRO project on teacher learning in the context of educational innovation, and is in the process of renewing its programme for supporting and rewarding teaching excellence.

UT will use Challenge-based learning and Teaching excellence as its major focus. Topics such as ethics in engineering education and entrepreneurial skills can be linked under the CBL theme and will be addressed in separate projects and activities. Several UT activities broadly implement CBL. 4TU.CEE emphasizes quality and an evidence-informed way of working, for example through a PhD study (co-financed). In the coming years, the Teaching & Learning Fellows will have the opportunity to innovate their education in an evidence-informed way (7 fellows from 2021-2023 and 7 new fellows from 2022-2024). The first 7 fellows will have a CBL focus. Within the broader Action cluster Recognizing & Rewarding Teaching (R&R), the action cluster UT Teaching Community (UT TC) is working on a model for further developing teaching excellence at the UT. The UT TC goal is to better connect professional development activities – from informal inspirational lunch meetings to formal trajectories such as SUTQ (Senior

University Teaching Qualification), and to promote the feeling of a UT community among teachers, emphasizing the importance of education. The aim is to also make a concrete connection to the Recognizing & Rewarding teaching framework in terms of performance criteria and career paths.

WUR will start up a PhD study on the Ethical and sustainable engineer. It will look at what is important in terms of mind-set and skills for students in this respect. How these are addressed currently in various curricula, and how such a mind-set and skills can be further stimulated and supported. WUR will also focus on ICT enhanced education, for example via its Ed-tech programme in which teachers can innovate their courses with new tools, provided these innovations are well supported and evaluated scientifically. WUR will continue its large projects in Teaching excellence. For example by contributing to the NRO project on teacher learning in the context of educational innovation; the PhD study of Marloes Vreekamp on the effect of pedagogical programmes for university teachers and the 4TU sector plan project on educational careers.

All universities will fund a joint project on Entrepreneurial learning, and participate in activities and projects around Teaching excellence.

Appendix 1: Mission, Vision and 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 the future"

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 fosters inspiring and effective engineering education within the Netherlands as well as abroad to prepare students for tomorrow's challenges.

Strategy

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

- Mapping recent innovations, trends, 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.

Appendix 2: 4TU.CEE Staff

4TU.CEE consists of a managing board, coordinators, researchers and ambassadors, each of which have their own work packages and responsibilities. Hereafter this will be explained in more detail.

4TU.CEE Board

4TU.CEE aims to be a small flexible organisation with a broad network of allied researchers and ambassadors. The board of the Centre consists of five leaders, supported by a coordinator. The board is responsible for managing 4TU.CEE.

The overall **chair** of 4TU.CEE is prof. P. (Perry) den Brok (WUR).

	Leader	Coordinator
UT	dr. C. (Cindy) Poortman	drs. C. (Chris) Rouwenhorst
TUD	prof. dr. M. (Marcus) Specht dr. ir. R. (Remon) Rooij	dr. R. (Renate) Klaassen
TU/e	prof. dr. B. (Birgit) Pepin	drs. C. (Caroline) Vonk
WUR	ir. E. (Emiel) van Puffelen	N. (Nicolette) Tauecchio

4TU.CEE Advisory Board

The Advisory Board is a sounding board and the conscience of the 4TU.CEE board. This board meets twice a year and reflects on 4TU.CEE plans and activities. The advisory board members also act as ambassadors of 4TU.CEE. The board consists of:

- dr. Kristina Edström (chair) (KTH)
- prof. dr. ir. Ines Lopez (TU/e)
- prof. dr. ir. Nieck Benes (UT)
- prof. dr. Marc de Vries (TUD)
- dr. Erik Heijmans (WUR)
- Ellen Siebers (Student UT)