

4TU.Centre for Engineering Education

Strategic plan 2019-2021



4TU. CENTRE FOR
ENGINEERING EDUCATION

March 2019



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 as well as (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. Both practical tools as well as scientific publications have been produced. 4TU.CEE projects topics varied widely from curriculum development to emerging technologies in engineering education. During the past year, dr. Jan van der Veen (Twente University) stepped down as chair of 4TU.CEE. During his chairmanship, the Centre developed from a new emerging initiative to an established and stable Centre in educational innovation for engineering education. As per September 2018, prof. dr. Perry den Brok (Wageningen University & Research) took over chairmanship.

For the upcoming years, 4TU.CEE will focus more in-depth on a smaller set of topics, rather than on a wide variety of topics. These topics on the one hand focus on envisioning the future of Engineering Education and on the other hand on supporting the development and implementation of innovations towards this future vision. The topics 4TU.CEE will focus on are:

1. Educating Future Engineers: defining engineering profiles and the professional identity of engineers; new competencies and skills for engineers, such as digital literacy skills, boundary crossing and entrepreneurial skills; establishing learning lines to realise the engineering profiles.
2. Interdisciplinary Engineering Education: organising and assessing interdisciplinary learning activities; collaboration between disciplines, cultures and practices; boundary crossing; interdisciplinary tracks and projects.
3. Engineering Educational Ecosystems: study teaching and learning in modern learning environments and conditions for rich and flexible learning; challenges, innovation spaces, incubators and extra-curricular activities; involving business and society beyond regular projects and internships; a learning focused view on augmented and virtual reality, blended learning solutions; dealing with growth and diversity in student influx.
4. Teaching Excellence in University Engineering Education: formulating frameworks for career paths for teachers; senior qualification trajectories in education; teacher learning during innovations and professional curriculum design or educational research communities.

4TU.CEE will continue to focus on a mixture of both practical outcomes as well as scientific outcomes. In the upcoming years we expect several 4TU.CEE funded PhD trajectories to be completed. Also, the centre will play a leading role in the organisation of the 2020 SEFI conference.

4TU.CEE will continue to organise and host workshops and invite international scholars to inspire teachers at the four universities. An example of this is the 'learning spaces tour' that is being organised during 2019.

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 by bringing together PhD students from different countries that study innovations in Engineering Education. Collaboration within the 4TU network will be intensified by scaling up successful local innovation projects to the other universities and by bringing together projects and findings under a smaller set of themes as described above.

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 do so, together with you as our partners! I hope you will like our strategic plan as presented in this document.

Sincerely,



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

Contents

Management Summary	3
Introduction	7
• Looking back (2014-2018)	7
• Strengths, weaknesses and opportunities for the future	8
4TU.CEE strategy for 2019-2021	11
• <i>More focus in themes</i>	11
• <i>Practical and scientific outcomes</i>	15
Organisation	18
• <i>Adjusting our method of working</i>	18
• <i>4TU.CEE staff</i>	19
Appendix 1: Mission, Vision and Strategy	20
Appendix 2: 4TU.CEE staff	21



Introduction

Looking back (2014-2018)

4TU.CEE had its kick-off in 2014, at that time still as 3TU.CEE. During the first two years, much effort was invested in setting up the organisation, including joint and local innovation and research projects. During the period 2014-2016, three research themes were pursued via teams consisting of joint researchers of the different universities (see the 4TU.CEE progress report 2015-2016 for more details): (1) comparing large-scale bachelor innovations at the 3 TUs, (2) investigating success and failure factors in educational innovations at the course and programme levels, and (3) interdisciplinary engineering education. Other themes were stimulated via local projects at the universities and included: awarding teaching excellence, engineering education for the future, student involvement and success, and feedback and collaborative learning. Different international experts (e.g. Graham, Mazur, Edstrom) came to visit the (then) three universities. A network of international contacts was established, and 4TU.CEE organised the 2016 CDIO European Regional Conference (at TU Delft).



During the years 2017-2018, Wageningen joined 4TU.CEE and it became a 4TU.Centre. During this period, the centre focused on a variety of topics, mostly via local projects conducted at the universities. The strategic topics during this period were: (1) future engineering skills (industry and research needs, entrepreneurial thinking, makerspaces), (2) curriculum development (engineering roles/profiles, team based learning, skills integration), (3) interdisciplinary engineering education (interdisciplinarity, assessment of interdisciplinary education, maths/physics integration), (4) emerging technologies (blended education, VR/AR, virtual labs), (5) sustainable engineering education (e.g. dealing with student growth, student diversity and internationalisation), and (6)

teaching excellence and continuous professionalisation. During this period, proposals were submitted to NWO and other research funds, the first articles and dissertations came to the fore, and there was increasing presence of 4TU.CEE at international conferences, such as CDIO and SEFI. 4TU.CEE organised the 2nd National Conference on Interdisciplinary Education (NIE at TU/e, 2018), and also various joint local study days at the local TUs, such as a study day on VR/AR in engineering education (Utrecht). Moreover, several international experts were invited and hosted workshops and lectures at the different universities: Prof. Siddhartan Govindasamy and Prof. John Geddes from Olin College (interdisciplinary education), prof. Thomas Reeves from the University of Georgia Athens (design research in education), Ruth Graham from the Royal Academy of Engineering (teaching excellence and the future of engineering education), prof. Babi Mitra from MIT (engineering education transformation).

Strengths, weaknesses and opportunities for the future

The past four years have led to a strong 4TU.CEE foundation. The 4TU.CEE board recognises the following *strengths*: 4TU.CEE is able to host and organise large events (CDIO, NIE, SEFI in 2020), and already has a strong international reputation (also visible in several international reports). It has been able to organise a good communication strategy. Teachers, programme directors, support staff and international scholars like attending the many workshops, study days and other tours and activities of 4TU.CEE. Our Innovation Map hosts well over 170 innovations and is being consulted during teaching qualification trajectories or when people prepare for innovation calls. 4TU.CEE has been able to work in cross-institutional projects, for example around large-scale bachelor curriculum innovations, interdisciplinary engineering education, diversity in education, the role of mathematics in engineering education, and new technologies in engineering education. Several projects are now producing high-quality scientific output, next to products for professional practice. 4TU.CEE has had considerable influence on local and international developments concerning vision development on engineering education for the future: 4TU.CEE board members have provided much valued input in their local university education visions, but also provided input for working papers of CESAER (EU network of deans of engineering education institutes) and CDIO.



4TU.CEE has a growing network in the four universities, and the network organisation is firmly established. 4TU.CEE members have been asked to join or participate in several local and national committees on engineering education, suggesting that the centre has achieved a good overview of the domain of engineering education. In some of the TUs, 4TU.CEE has become visible and supportive in local innovation tenders, and in important working groups or task forces around university education. The 4TU board of education regularly invites 4TU.CEE to provide an update on important topics concerning education, such as learning analytics, educational vision, and interdisciplinary education.

The 4TU.CEE board also acknowledges selected weaknesses, areas for development, which are important for its continuation in the future. One of these relates to the time it has taken 4TU.CEE to become fully engaged in the universities' differing projects, and even now not every department is engaged in 4TU.CEE funded projects. Hence, at some universities there is still an under-spending of budget. This is often due to lack of time or lack of incentives for staff to participate. While covering the field of engineering education can be considered a strength, it can also lead to a lack of focus or 'doing many things and becoming the master of none'. It is important to focus on fewer issues, and investigate those chosen ones more in-depth. 4TU.CEE could improve its profile and influence in that respect. A focus on selected themes and projects, studied from different perspectives and in different contexts is likely to be beneficial.



First steps have been taken in this respect: for example, at each of the TUs more long-term studies have been started, often in the form of PhD trajectories. These studies focus on important and complex topics, such as how to support teaching staff in redesigning their education, how to use design toolboxes or other innovative materials in hands-on engineering courses, and how to integrate engineering content with social science content, to give a few examples. This will also help in establishing a growing impact of 4TU.CEE in terms of both its practical as well as evidence-based output (e.g. articles, keynotes, dissertations, grants). During the past period 4TU.CEE has already realised considerable practical output, including publications and workshops. As the first PhD trajectory sponsored by 4TU.CEE has led to a dissertation in 2018, with several more to come in the upcoming period, the scientific output is expected to increase, adding to peer-reviewed journal publications and well-received engineering education vision publications.

The future also holds interesting *opportunities* for 4TU.CEE. Emerging topics that obtain much attention and funding at the moment are the innovative learning contexts (e.g. maker spaces, innovation spaces, incubators, living labs, etc.), new approaches to curriculum organisation (e.g. micro-credentialing), maintaining quality of education with growing student numbers (especially for the more hands-on courses and internships, or theses), linking extracurricular activities to the curriculum (e.g. student challenges), balancing online and face-to-face education, and rewarding excellence in teaching at university level (including senior qualifications on teaching). More grants are becoming available for research on higher education, e.g. NRO funds, NWO Comenius grants, SURF innovation funds, and EU themes for research. 4TU.CEE could apply for these funds, as a consortium, to ensure continuity in research, or even further strengthening its position. Finally, 4TU.CEE could further support developments within certain engineering domains where educational research and innovation are coming more to the fore, such as the domains of Industrial Design, the Built Environment, Technical Medicine, Civil Engineering, and Mathematics and Informatics. 4TU.CEE could further position itself as expert in evaluation of educational innovation.

4TU.CEE strategy for 2019-2021

More focus in themes

One of the driving forces behind future engineering education and current developments in engineering education is the need for training new professionals and the support of existing professionals in dealing with the grand challenges of the future (the Sustainable Development Goals as posited by the United Nations; the Grand Challenges for Engineering as put forward by NAE). These problems are so complex and multidimensional that they require the contribution of various types of engineers, or engineers to collaborate with many other parties and stakeholders in society, the combination of expertise from different domains – both within engineering as well as between engineering and the social sciences - and the development of scientific, design and other skills (e.g. creativity, entrepreneurship, digital literacy). This in turn requires new types of learning contexts that are rich, authentic, multi-dimensional, multi-actor, and aimed at a variety of outcomes. Teachers play different roles in these contexts, different to the roles they played in traditional education, and this requires new competencies and further professionalisation.

4TU.CEE will focus its efforts on a more limited set of topics, those that relate to the need for engineering education for the future. These main topics also link well to strong 4TU.CEE themes of the past four years, and together they comprise the major educational elements of engineering education: from students and goals to the content of learning, the learning environment and the role of teachers.



The strategic themes for 2019-2021 are:

1. **Educating future engineers** – This theme deals with different engineering profiles and the development of the professional identity of engineers (from technical orientation to more entrepreneurial or societal orientation) that are needed to develop future-proof engineers, who are able to contribute to the sustainable development goals. It also deals with the new skills and competencies that future engineers need, such as digital literacy skills, boundary crossing skills, entrepreneurial skills and creative and critical thinking. Finally, the consequences of these new profiles and skills for the curriculum of engineering programmes are important: what teaching strategies work best? How can skills be best integrated and assessed, also as part of learning lines? Projects to be started or undertaken under this theme will focus on future engineering roles (TU Delft), creating learning lines for 21st century skills (WUR), computational thinking (TU Delft), and developing future engineering skills (UTwente).



2. **Interdisciplinary engineering education** – Engineering education is becoming more interdisciplinary by nature. How can interdisciplinarity be best organised in learning activities, curricula or assessment? What types of interdisciplinarity exist and how different are they; what makes integrating different engineering domains work? What makes combining engineering domains with social science domains work? How can students and teachers learn to collaborate in interdisciplinary teams? What role do ethnicity and culture play in (interdisciplinary) collaboration? How can different other actors from society be engaged in interdisciplinary engineering projects? Projects (to be) undertaken under this

theme will be the creation of a university-wide framework and toolkit for boundary crossing competences (boundaries related to disciplines, cultures and practices) in connection with a recently obtained NWO Comenius Leadership Grant (WUR), reviewing interdisciplinary engineering education research and practices (TUD, TU/e and UTwente), prototyping in education (TU Delft), developing and mapping engineering identity between university and companies (project Bridge the Gap, UTwente) and developing and evaluating Joint Interdisciplinary Master Projects (TU Delft).

3. **Engineering educational ecosystems** – Modern engineering education contexts allow for multiple stakeholders, links to society, learning at multiple locations, and using ICT in a smart way to support for this. How can educational ecosystems be best organised? What does learning look like in so-called makerspaces, innovation spaces, or incubators? How can extra-curricular experiences, such as challenges and living labs, be linked to curricula or ‘validated’ via diplomas? What role do teachers play in these new types of environments? How can business and society be involved more, beyond traditional projects and internships? What learning outcomes are realised in such environments and how can they be best assessed? What role can blended education or new technologies, such as Virtual and Augmented Reality play in effective and rich learning processes in engineering education? How can ICT help to enable more flexible and personal learning paths, or how can it help in more effectively and efficiently dealing with growing and more diverse student populations? Examples of projects 4TU.CEE will undertake under this theme are evaluating blended education and ICT-based redesign of engineering courses (TU/e, WUR), VR in engineering education (UTwente, TU/e), mapping learning experiences and learning gains in makerspaces (TU Delft, TU/e), the innovation space as design environment (TU/e), small-scale hands-on education (TU/e), self-regulated, peer-regulated and project-based engineering education (UTwente), summative and formative digital testing (UTwente).
4. **Teaching excellence in university engineering education** – Universities are creating career paths for their staff, also with respect to teaching. They are expanding their professional development portfolio with respect to new developments and innovation in engineering education, and creating opportunities for life-long learning, also using ICT as support. Can the framework for teaching careers (Graham, 2018) be fruitfully used to support these developments? How can senior qualifications in education be best developed? How can such trajectories be linked to innovation projects and innovation calls? What do teachers learn during these trajectories? What role can 4TU.CEE play in supporting this learning? Projects started or continued under this theme are stimulating teachers to innovate education via an education fund or bottom-up innovations (TU/e, UTwente, TU

Delft), stimulating education design communities of teachers (WUR, UTwente, TU/e), establishing teaching fellowships (UTwente) and coaching teachers during senior qualification projects (UTwente, TU/e). All four TUs will also participate in research and workshops organised by the Royal Academy of Engineering (Ruth Graham) and exchange their practices in this respect.



The projects and activities described under the four 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.

Practical and scientific outcomes

4TU.CEE undertakes several activities to disseminate research, good practices and tools for innovative engineering education to teachers, educational managers and researchers. This is, for example, done by providing access to innovations through our online Innovation Map and by offering thematic workshops and interactive lectures at the four universities. At the same time 4TU.CEE staff also visits engineering universities abroad to become inspired and learn about innovations they have implemented on topics described above.



4TU.CEE engages in research and activities on a variety of topics, typically via projects. These projects include both short-term practice-oriented projects, exploratory studies to identify promising practices, as well as more fundamental PhD studies. As a consequence, expected and anticipated outcomes of these projects and activities support the mission of 4TU.CEE, and focus on both practical as well as scientific audiences.

Types of *scientific* output 4TU.CEE hopes to deliver in the upcoming period encompass the following:

- Deliver doctoral dissertations based on 4TU.CEE funded or supervised PhD projects, including accepted or published international peer-reviewed scientific articles and conference presentations as part of these dissertations.
- Participate in and ideally obtain grants for research in the domain of engineering education via research calls (e.g. NRO higher education; NRO fundamental research; Comenius; SURF Open and Online).
- Continue to be annually present at the most important research conferences in the domain of education and engineering education (e.g. Educational Research Days, SEFI, CDIO, EARLI, ECER, etc.).
- Collaborate in or support scientific publications based on local projects and exploratory studies, or smaller innovation projects that have been conducted by university staff and have been funded by 4TU.CEE.
- Presence via practical publications based on conducted studies, for example via contributions in local university newspapers, or journals on higher education.
- Report on interesting projects via the regular 4TU.CEE channels, such as the 4TU.CEE blog, the 4TU.CEE newsletter.
- Deliver keynotes for important partners or stakeholders.



Types of *practical* output 4TU.CEE aims for:

- Be present as 4TU.CEE board or coordinating members in relevant innovation committees or education task forces at our own universities.
- Present practical and scientific insights in relevant networks, such as CESAER, the Royal Academy, and to relevant stakeholders, such as the 4TU Education board, educational directors, to name a few.
- Further increase the number of innovations disseminated via the Innovation Map and via our newsletter.
- Disseminate materials, tools and other outcomes of projects, for example via the Innovation map.
- Organise, co-host or support innovation/teacher days at each local university.
- Organise workshops given by national or international experts annually or organise study tours. In the upcoming two years, we will be organising for example a study tour to innovative learning environments (the 'learning spaces tour').
- Organise local sessions, workshops or lectures on relevant topics or exemplar projects to teaching staff at each local university.
- Stimulate the implementation of successful innovation projects more widely within our universities.
- Create a network of innovation experts, with staff in different faculties acting as innovation ambassadors.

More in general, 4TU.CEE aims to contribute to new ideas, construct new frameworks, provide input for university visions and helps to implement these. We want to show educational leadership in our four themes, and be regarded as experts in them. This becomes visible in references to 4TU.CEE work or 4TU.CEE members in vision documents, major reports by external parties, international collaborations, keynotes presented, and so on.

The upcoming period, we also have some concrete milestones we want to achieve:

- We (co)organise the SEFI conference in Twente in 2020, and use it as a showcase/window for our work!
- We aim to host and publish a special issue in an engineering education journal, or create a volume/book in a book series (for example, the Brill series Advances in Learning Environments).
- We are visible in the supervision, outcomes and processes concerning advanced teacher professional development in higher education, for example the Senior Qualification in Education.

Organisation

Adjusting our method of working

During the first 4TU.CEE period we engaged in many joint activities, during the second period we mainly engaged in local activities organised on a relatively large and wide set of themes. In the upcoming years, we will focus on a smaller set of themes, and will intensify our 4TU.CEE collaboration again, both internally within the 4TU federation as well as with national and international partners. We will strengthen our internal 4TU collaboration in a number of ways:

- By creating a specific set of joint projects, particularly via research grants.
- By conducting projects also in other 4TU.CEE universities, instead of one's own university.
- By exchanging the findings from local projects more with other (4TU.CEE) universities.
- By starting projects in one of our universities, then scaling up or expanding to other 4TU universities (see for example the teaching excellence framework project).
- A large part of the projects will remain local, but will be more linked under common themes.

One major challenge we face is that our staff at the university has previously been given little time and resources for innovation and evaluation work, and we observe that expertise for engineering education projects is not always available. As a result of strategic funds provided by the Ministry of Education, universities are expected to increase these resources, which also provides opportunities for 4TU.CEE to cooperate and interact with teaching staff. In addition, to minimise the effect of these challenges, 4TU.CEE will work smartly and strategically. One way in which this becomes visible is via our focus on a smaller set of themes, another way is by linking innovation projects to other work we do, by applying for grants to obtain extra capacity via PhD students or assistants, and by involving master thesis students or internship students to our projects, when and where possible or suitable.

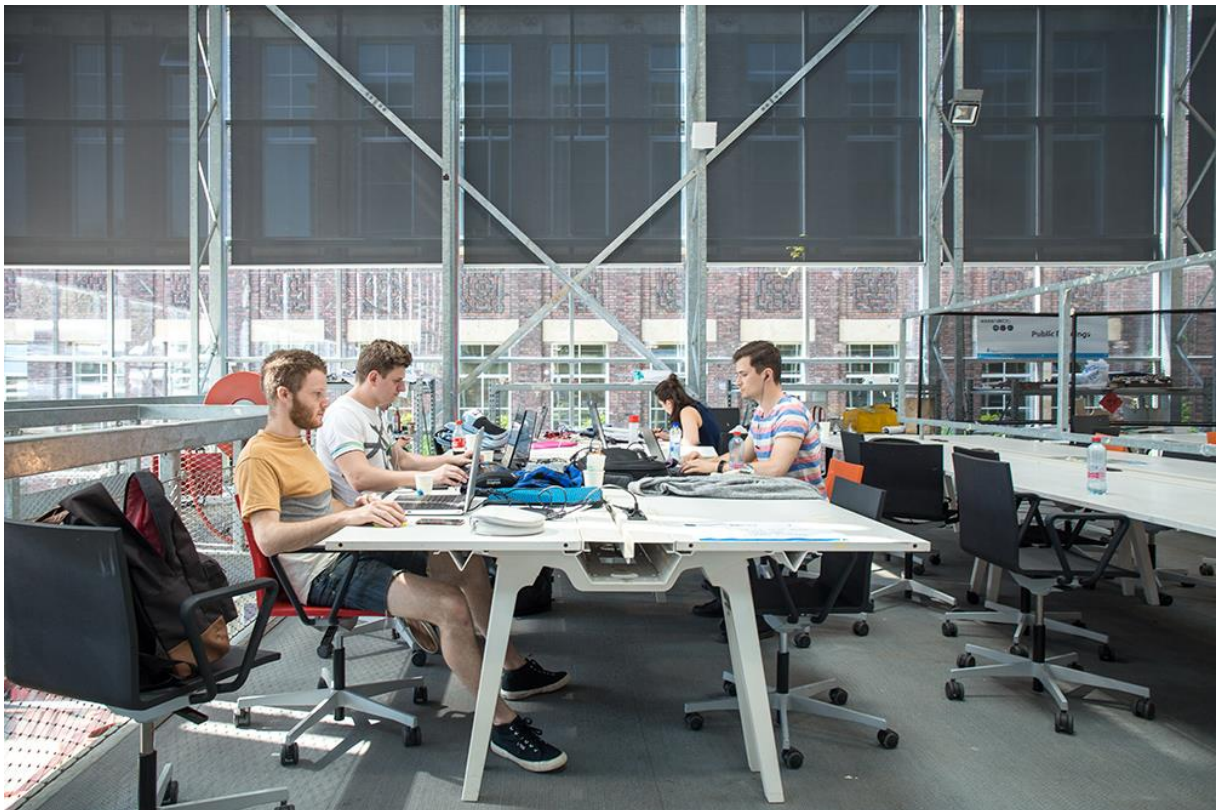


In addition, we will further intensify our international and national collaboration and aim to make these collaborations more structural. One way of doing so is by bringing together the 4TU.CEE funded PhD students with PhD students from other countries. 4TU.CEE already has contact with KU Leuven, EPFL Lausanne, Chalmers and IUPN. Another way of doing so is by

organising inspiration trips to partnering universities and by organising international events. 4TU.CEE for example is involved in the organisation of the 2020 SEFI conference and contributes intensively in CDIO events. Nationally, 4TU.CEE has contact with the education research section (NRO) of the Netherlands Organisation of Scientific Research (NWO), for example around the establishment of a national database on educational innovations in higher education, the Centre for Education and Learning of Delft, Rotterdam and Leiden University (CEL) which mainly focuses on ICT in education.

4TU.CEE staff

Appendix 2 provides an overview of the people involved in the 4TU.CEE Board and Advisory Board.



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 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

 4TU.

Appendix 2: 4TU.CEE Staff

The 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 four leaders, each supported by a coordinator. The board is responsible for managing 4TU.CEE. The daily activities as well as building the Centre are a responsibility of the coordinators.

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

	Leader	Coordinator
UTwente	dr. J.T. (Jan) van der Veen	drs. C. (Chris) Rouwenhorst
TU Delft	ir. A. (Aldert) Kamp	dr. R.G. (Renate) Klaassen
TU/e	prof. dr. B.E.U. (Birgit) Pepin	C.H.T.A. (Chantal) Brans Msc
WUR	Ir. E.A.M. (Emiel) van Puffelen	

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 the 4TU.CEE plans and activities. The board members also function as ambassadors of the Centre. The board consists of:

- Dr. Kristina Edström (chair) (KTH)
- Prof. dr. ir. Lex Lemmens (TU/e)
- Prof. dr. Rikus Eising (UT)
- Prof. dr. Marc de Vries (TUD)
- Dr. Erik Heijmans (WUR)
- Christiaan Meijer (Student TUD)