

Engineer of the Future - Future of Engineering Education

Midterm Progress Report 2022-2023

TU Delft Delft University of Technology

TU/e Eindhoven University of Technology

UNIVERSITY OF TWENTE.

WAGENINGEN University & Research

4TU.

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Photo: Michiel Poudersrijen

Introduction Midterm Progress Report 2022-2023

By Remon Rooij, chair 4TU.CEE

CEE is halfway through its strategic period 2022-2025; a very nice moment to look back and forward, and reflect on our achievements and future ambitions. This post-COVID time brought our institutions and our teaching practices new opportunities and challenges, but many also have remained the same: our ambition to strive for the best engineering education possible, to develop value-based (sustainability!) and evidence-informed (pedagogical research!) education innovations, and to inspire and support our staff to become better educators every day.

Centre of Expertise and Collaboration

We are proud to say that the 4TU Centre for Engineering Education (CEE) is an established centre of expertise and collaboration. During international events, we hear from our international colleagues that they envy us for having such a successful national platform; for exchanging experiences and expertise on the one hand, and jointly – within and across our four universities – setting up innovative teaching

practices and doing pedagogical research on the other. Since 2022, we have started to talk to the University of Groningen to collaborate within CEE. An agenda of shared interest has been produced and an agenda of shared projects will come.

And within our four institutes, CEE collaborates intensively with various local university teachers, pedagogical researchers, educational advisors, educational leaders, and policymakers. So, for many CEE is a preferred partner to talk to for any engineering education-related question.

Our [Innovation Map](#) with about 300 innovation and/or research projects is a recognised example of how to open up our expertise to the world. And we started an open access book series on Higher Engineering Education – research and Innovation (HEERI) in co-operation with TU Delft OPEN and with an editorial board coming from 4TU.

PhD and Postdoctoral projects

We are extremely proud of our PhD candidates and postdoctoral researchers. Several projects were finished and started in the '22-'23 period.

In November 2022, Rike Bron defended her PhD thesis on [Collaborative course design in higher education - a team learning perspective](#). In particular, we are happy to say that we have been able to establish a 4TU-wide community on Entrepreneurial Engineering Education (EEE) in collaboration with the institutional centres of entrepreneurship. CEE has sponsored both an EEE PhD and an EEE postdoctoral project. Also for the themes Learning Analytics and Challenge Based Learning we have built strong ties between our universities.

Unfortunately, COVID-19 times also frustrated several of our CEE projects. We have been looking at how to wrap things up in a satisfactory way.

CEE for Teachers and for Advancing our Teaching Culture

CEE aims to inspire and support our university teachers and simultaneously advance a positive teaching culture in our institutes. In 2022, the Teaching Culture Survey had its second run. Our long-lasting partner Dr Ruth Graham leads

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both this longitudinal research project and the international Advancing Teaching network. Compared to the TCS2019 results, our teaching cultures change for the better in our institutes, but (very, and for many too) slowly. The 4TU rectors asked CEE for advice on how to catalyze this process of (cultural) change and have more impact on the work floor.

CEE is also one of the leading institutions in the NRO-supported TEACHERS2LEARN research project that studies how teachers learn and professionalize in the context of educational innovations in higher education.

Events

4TU.CEE was involved in the organisation of large conferences and workshop series, such as the 2023 SEFI European Convention for Engineering Deans in Twente on the digitization of engineering education, the 2023 first national Challenge Based Learning conference in Eindhoven, the 2022 Advancing Teaching network meeting in Amsterdam, the PhD Practese symposiums with KU Leuven and

“CEE aims to inspire and support our university teachers and simultaneously advance a positive teaching culture in our institutes”

the University of Western Australia, the 4TU CBL webinar series, the 4TU Learning Analytics webinar series, and many more smaller events.

It is also great to see that 4TU's presence is very high at the best-known international annual conferences on engineering education. Our Dutch community of engineering educators is visible and warmly welcomed because of their constructive contributions at the European (e.g. SEFI) and global (e.g. CDIO) levels.

Personnel changes in the board | 6

In the 2022-2023 period, CEE leadership has known several personnel changes. Prof. Perry den Brok (WUR) stepped down as CEE chair and handed his position over to Dr Remon Rooij (TUD). In Eindhoven, the scientific lead Prof. Birgit Pepin has been succeeded by Prof. Esther Ventura. In Delft, the CEE coordinator from CEE's first hour Dr Renate Klaassen has been succeeded by Vera Scheepens. In Twente, Luuk Buunk joined CEE as coordinator in 2022 but left in 2023. Priyanka Pereira has become his follow-up since January 2024. In January 2024, Emiel van Puffelen stepped down as WUR's scientific lead, and a new WUR team is already in place: Dr Judith Gulikers (scientific lead) and Stijn Heukels (coordinator). Nienke Nijenhuis is our new communication officer, and we also had a change of several Advisory Board members.

Future outlook

CEE's strategic agenda for 2022-2025 and related projects are well on their way. For the CEE board, 2024 will also be the year to look further ahead: 2026-2029. Together with our Advisory Board and many colleagues and students (!) from within our institutes, we will discuss and set our priorities for the years to come. Without any doubt, our discussions will be organised around four core questions:

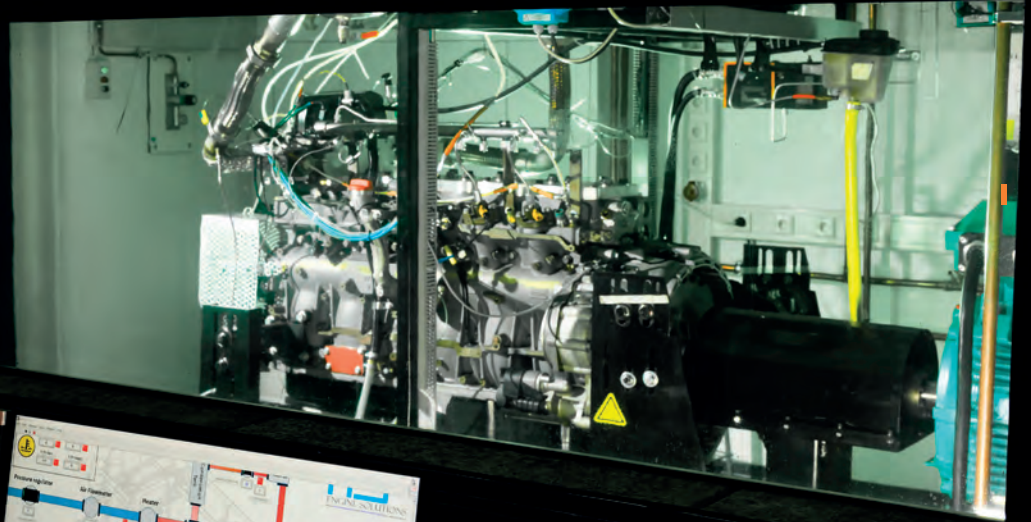
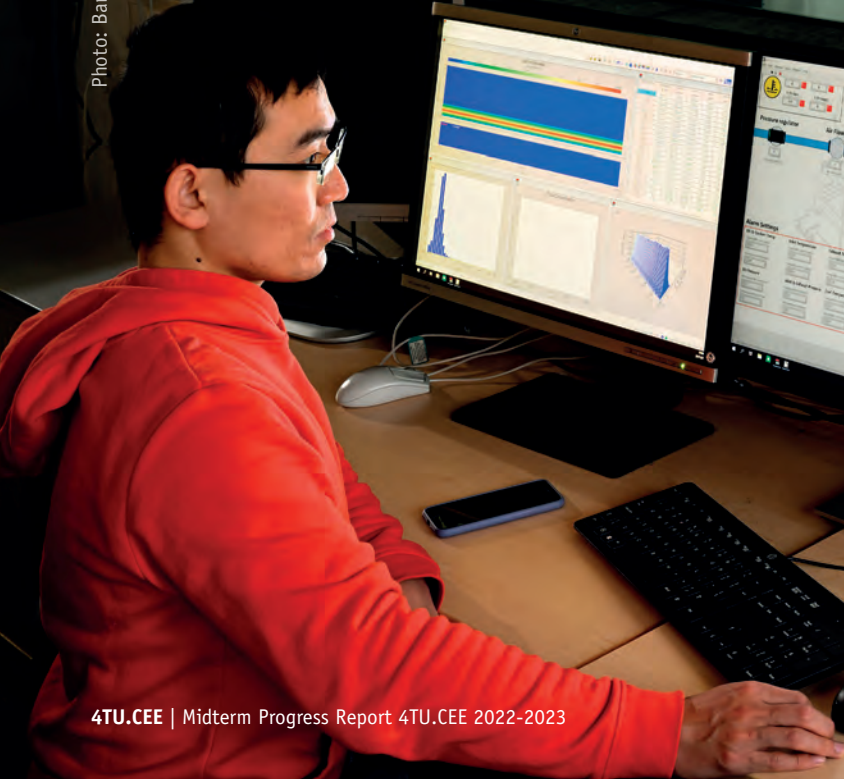
- *What makes future-proof engineers?* That is: the **student's** perspective.
- *What makes future-proof engineering educators?* That is: the **university teacher's** perspective.
- *What makes future-proof engineering education?* That is: the **programme** and supporting organisations' perspectives.
- *What makes a future-proof engineering university from the point of view of teaching and learning?* That is: the **institutional** and educational policy perspectives.

The board is looking forward to developing an inspiring innovation and research agenda for the coming years.

Finally, a warm word of appreciation should go to our core team of scientific leaders and programme coordinators. Because of their full commitment to our ambitions, CEE is what is it: a very knowledgeable community with a very positive and collaborative way of doing things.



MX13 with PhD student Zhongcheng Sun. The mission: climate-neutral and future-proof mobility for people and goods by 2050. Focus: on transport (cargo traffic and the shipping industry) with traditional internal combustion engines that run on sustainable fuels. Therefore, the combination of ultra-efficient internal combustion engines and renewable fuels is key to accelerating GHG emission reduction.



On the following pages you will find a selection of activities and projects, conducted during the period 2022-2023.

Engineer of the Future

1. Entrepreneurial Engineer
2. Digitally Literate Engineer
3. Responsible Engineer

Future of Engineering Education

4. Challenge Based Education
5. ICT-Enhanced Engineering Education
6. Teaching Excellence

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For each of the six themes and chapters, we will provide a short description of the theme and present a selection of flagship projects, activities, events, and/or achievements. A more complete and detailed overview of those and the people involved can be found on our 4TU.CEE website: [Innovation Map](#), [Publications](#), [Event agenda](#), and [News items](#), including our Newsletter and BLOG.

Between and within the portfolio chapters you will also find several Intermezzos: miscellaneous kind of achievements that we are proud of but that are somewhat harder to put under the umbrella of our portfolio themes.

In the last chapters, we present an overview of a select number of key publications, keynote speeches, key media appearances, and key events led by CEE staff. Additionally, you will find an overview of all our postdoctoral researchers, PhD candidates, and master's students.

The 4TU.CEE Midterm Progress Report 2022-2023 can be found [here](#).



1 | Engineer of the Future Entrepreneurial Engineer

This first theme refers to the entrepreneurial context of engineering. More than ever society is in need of engineering professionals with entrepreneurial mindsets and attitudes, innovation and creativity skills. They are the ones who look for opportunities, create (added) value, dare to take risks and initiative, can cope with uncertainty, complexity, and ambiguity, show vision, perseverance, and (self) leadership, and learn through experience and co-creation.

4TU Entrepreneurial Engineering Education community

To deal with complex societal and organisational challenges, companies and governments hiring engineers increasingly look for professionals trained to innovate; who can, in addition to contributing to the technological feasibility, contribute to the desirability (society level), viability (business level), and organisability (human level) of new technological ideas.

Beyond the often-praised disciplinary qualities of Dutch engineers, future engineers will need additional competencies, here termed as entrepreneurial engineering competencies. The [inaugural lecture](#) of Frido Smulders, who explicitly refers to 4TU.CEE here, sets the scene nicely.

To address this challenge 4TU.CEE has sponsored the development of a 4TU-wide EEE community in close collaboration with the local centres for entrepreneurship. Within each institution, we build a similar structure: Special Interest Groups (SIG) consisting of teachers interested in taking

up the challenge of embedding modules on entrepreneurial engineering within their existing courses. A PhD candidate and a postdoctoral researcher have been installed. The team has developed a conceptual framework representing the entrepreneurial side of technological innovation. The framework serves as a reference for developing educational modules (for students and university teachers) and while doing so will be improved over time.

PhD project - Entrepreneurial Learning

The PhD project by Victor Garcia Galofré emerged from 4TU.CEE's ambition to educate future engineers with an entrepreneurial mindset enabling them to deal with grand societal challenges as recognized by the United Nations in the Agenda 2030 and specified towards the Sustainable Development Goals.

These grand societal challenges require that we educate T-shaped engineering students who develop skills not only focused on technical expertise but also on developing an entrepreneurial mindset allowing them to shape solutions with different actors (e.g. peers, teachers, stakeholders) in an iterative process of multiple value-creation that is spiced by uncertainties. To embed the development of an entrepreneurial mindset in engineering degree programmes, technical universities require evidence-based education interventions on entrepreneurial engineering for sustainability. These interventions need to be designed from a wide entrepreneurship approach, which is focused on learning through entrepreneurship – providing entrepreneurial skills and attitudes in the context of multiple value creation.

Therefore, the main purpose of this PhD project is to develop evidence-based materials for education facilitating the student in developing towards the entrepreneurial engineer for societal impact. First, based on the literature and through a Delphi study among faculty and practitioners, the profile of the entrepreneurial engineer is created. Next, the effects of existing (wide) entrepreneurship education interventions for engineers are tested and best practices, gaps and needs will be detected. Finally, new interventions to foster the entrepreneurial engineer are developed, tested, and monitored.

Currently, are analyzing the first round of the Delphi study. We observed that there is not one specific profile but various perspectives to take into account. Therefore, we are drafting different profiles of Entrepreneurial Engineers with the support of literature. By developing these profiles, we expect to be able to track them in the context of the 4TU and gain awareness of what is currently being done. This will contribute to detecting the above-mentioned gaps, needs, and opportunities to provide further insights and interventions on how to educate such engineers.

Postdoc project - Teaching for Entrepreneurial Engineering

This postdoctoral research project by Ufuk Gür starts from the premise that educating the entrepreneurial engineer requires new teaching approaches. The core assumption is that engineering discipline educators are the change agents for the transformation of engineering education

into (more) entrepreneurial engineering education. The Train-the-Trainer programme in Entrepreneurial Engineering creates a learning hub for engineering lecturers who are interested in bringing entrepreneurship and innovation theory and knowledge into their regular engineering courses. The learning hub includes theory-based sessions, online modules, workshops, coaching for course/module design, and a special interest group for entrepreneurial engineering lecturers. A first and second round of sessions for university teachers took place in 2023.

The project-specific objectives are:

- Enhancing the knowledge about the theory and practice of entrepreneurial engineering through design research.
- Contributing to the lecturers' professional development through an entrepreneurial engineering education lens.
- Encouraging the transformation of engineering courses with incremental changes.
- Creating a community of practice for university teachers to share and reflect on experiences.

BK-Launch

4TU.CEE is one of the Partners of [BK-Launch](#), the platform for innovation and encouragement of entrepreneurship in the faculty of Architecture & the Built Environment (Bouwkunde), at Delft University of Technology. Its goal is to create an entrepreneurial community for student ventures, with a vision to transform the built environment for the better: more

circular, more resilient, more fair, more healthy, etc. Driven by ambitious students active with a (future) venture in the Built Environment. Facilitated by faculty members and Partners whose knowledge, expertise, and investment constitute the foundation of the platform.

What makes this platform special, is the growing network of advocates of entrepreneurship that form an academic source and example for future entrepreneurs. Their stories and experiences, together with the foundation laid by the partners serve two MSc elective courses that are meant not only to teach students about the importance of entrepreneurship but also to help their great ideas become potential future ventures. Hundreds of Bouwkunde students have already experienced the opportunities that BK-Launch brings them. However, BK-Launch does not stop there. It aspires to achieve a real-life BK-Launch MAKE IT space that serves as an incubator for exceptional ideas.

Webinar entrepreneurial engineer

As part of the CBL webinar series, CEE organised a webinar in November 2022 on entrepreneurial engineering education and CBL. Three colleagues presented their work in this webinar. From TU/e Gert Guri presented his experiences from working in InnoSpace with students on their Bachelor End Projects. From the joint 4TU.CEE project on entrepreneurial engineering education PhD candidate Victor Garcia Galofré (TU/e and WUR) and postdoc Ufuk Gür (TUD and UT) presented their ongoing research. The global SDGs are spiced with complexity and uncertainty, and have

“The Entrepreneurial Engineering Education (EEE) theme develops new teaching approaches and new profiles of the entrepreneurial engineer with the aim of providing relevant learning experiences.”

a value-laden character that can be addressed in higher education through value-creation pedagogies. In this perspective, the Challenge Based Learning pedagogy offers an adequate learning framework to educate the professionals of the future with an entrepreneurial mindset by enabling students to provide feasible and impactful solutions to real-life challenges. This webinar presented a theoretical approach to understanding entrepreneurship education from a value-creation perspective and showed specific value-creation cases that are currently running at TU/e.

In a wider sense, entrepreneurial engineering holds a contextual meaning for existing organisations as intrapreneurial engineers engage in the practice of innovating technology. As an evolving research stream, investigations about the role of the entrepreneurship educator in engineering education prevail. CBL can bring entrepreneurial engineering practice and experience into the learning environment. Those challenges might especially include the multi-level aspects of the practice such as the individual level (role-based), project level, team level, organisational, inter-organisational, and institutional level challenges which are completely aligned with the stakeholder view of CBL.



INTERMEZZO

4TU in SEFI

SEFI is a non-profit international organisation and is considered the largest network of engineering education players in Europe active since 1973. SEFI's members are institutions of higher engineering education, rectors, deans, professors, and students, but also companies, and other international associations and societies involved in the field.

The mission of SEFI is to contribute to the development and improvement of engineering education in Europe, to emphasize the need for and to strengthen the image of both engineering education and engineering education professionals in society.

4TU.CEE and 4TU staff continue to engage and contribute to the SEFI community. These last two years we have had a number of contributions of papers and workshops related to 4TU.CEE sponsored projects in the Annual Conference.

You can find our 4TUs contributions in the SEFI Conference Proceedings. A highlight of the engagement of 4TU.CEE and SEFI was the SEFI Deans conference hosted at University of Twente and sponsored by 4TU.CEE in 2023.

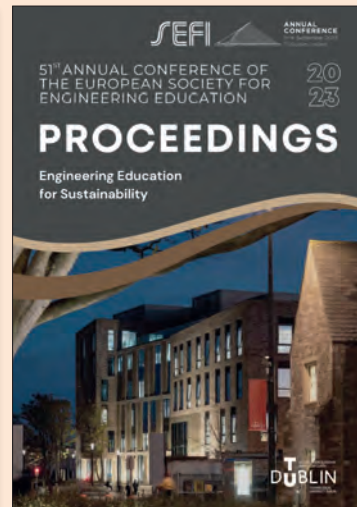




Photo: Bart van Overbeeke Fotografie, TU Eindhoven

2 | Engineer of the Future Digitally Literate Engineer

The engineer of the future will work in a further digitised and digitizing world. Data will be ubiquitous and understanding the value, relevance, and limitations of data become key, as well as data security and privacy issues. So, this second theme refers to digital literacy and information skills, digital collaboration skills, and using digital tools to conceive, design, implement, and/or operate engineering interventions. Industry 4.0 and 5.0 refer to people working with and alongside robots, AI, smart machines, etc.

SEFI Deans Meeting UT/4TU – Leadership for digitalization in higher engineering education

On the 24th - 26th of May 2023, 4TU.CEE organised the [SEFI European Convention for Engineering Deans \(ECED\)](#) on the campus of the University of Twente: Leadership for Digitalization in Higher Engineering Education. We welcomed more than 70 participants from different European countries and beyond in Enschede, to discuss the future of engineering education with a strong focus on digitalization and innovation. The programme included keynotes about vision on engineering and engineering education, digitalization, and professional development projects. We also organised discussion panels and workshops about sustainable education innovation and educational leadership.

Among the speakers and discussants were Prof. Pierre Dillenbourg, Prof. Marcus Specht, Aldert Kamp, Prof. Kim Schildkamp, Prof. Esther Ventura, Prof. Perry den Brok, Dr Cindy Poortman, and Prof. John Mitchell.

Dr Balázs Vince Nagy (current SEFI president) moderated the Industry stakeholder expert panel that was organised for the first time at ECED and highly valued both by the industry partners and the audience. Prof. Gerhard Müller and Prof. Luis Manuel Sánchez Ruiz, as (SEFI) council co-chairs, provided their wrap-up of the convention by suggesting Twente Thoughts about joint vision, transformation, leadership, and digital formats. Thoughts that need to be further addressed are about “great individuals versus scaling up/how to steer innovation”; “flight level of goals versus achieving innovation, and providing related resources and support”; “critical thinking versus leadership cultures”, and “AI in education versus (EU) AI regulations”, to name but a few.

Quantum Programming

The goal of the Think Q project, co-funded by CEE, is to develop educational tools and materials to teach students of the engineering disciplines how to use (future) quantum computers. As part of this TU Delft project, the Quantum Expression [Template Library LibKet](#) has been developed together with a [set of tutorials](#) that were used at several occasions, i.e. QCE '21 and '22, and SIAM CSE '21, and at the Lecture series “Introduction to Quantum Computing in Fluid Dynamics” at the Von Karman Institute for Fluid Dynamics in Belgium, which will have its second edition in July 2024.

Based on the experience gained from developing these entry-level tools that aim at getting students without prior knowledge in quantum computing interested in this emerging technology, the PI's group has

explored more advanced applications for quantum computers. One of them is computational fluid dynamics (CFD), which is one of the most demanding computational applications today pushing even the largest supercomputers to their limits. At the same time, CFD is omnipresent in academic research and industrial R&D ranging from bio-medical applications such as patient-specific heart-valves to the optimal design of next-generation aircrafts.

The PI's group belongs to the leading pioneers in the field of Quantum-CFD. Recently, his group started a long-term collaboration with Fujitsu Research to advanced Quantum-CFD to a TRL that will enable its practical usability on future fault-tolerant quantum computers.

ChatGPT in engineering education

The biggest game-changer in 2022/2023 concerning the digital literate engineer has been the breakthrough of generative AI after the launch of ChatGPT. In a very short time, ChatGPT proved that AI will have an irreversible and disruptive influence on (engineering) education. Like other education institutions, the 4TUs have not yet decided how to integrate this into education.

In 2023 the TU/e Innovation Fund has supported several pilots and research projects that look into this topic. There is a project that looks into ethical guidelines for the responsible use of AI generative tools in engineering education: [Ethical guidelines for the responsible use of AI generative tools in engineering education \(4tu.nl\)](#).

Another project researches AI and engineering education with a focus on assessment. A third project researches the use of ChatGPT in science teacher education across the 4TU [Embracing the future: the use of ChatGPT in Science Teacher Education \(4tu.nl\)](#). The results from these projects are expected in the second half of this strategic period. Furthermore, the topic was the subject of a hybrid lunch session for 4TU colleagues; teaching, support, and research staff were present.

Conference Computational Thinking

In June 2022, the TU Delft co-organised the International Conference on Computational Thinking with the Education University Hong Kong and CoolThink@JC. As a key topic to the challenge of developing digital skills for future engineers and embed the development of these skills already in the school curriculum the conference highlighted achievements and ongoing research for the development of programming and computational thinking skills.

APSCE CTE-STEM stands for International Conference on Computational Thinking Education and STEM Education. CTE-STEM 22 has been the 6th international conference organised by APSCE. The conference proceedings are available open content and have been published with TU Delft Library. The conference topics have been ranging from teaching programming schools, assessment of Computational Thinking, to game-based learning and STEM education.

“In a very short time, ChatGPT proved that AI will have an irreversible and disruptive influence on (engineering) education. Therefore, we have put several projects in motion to see how we should integrate generative AI into education.”

Digital Skills

Digital Skills are becoming increasingly important in the work of engineers. Just like mathematical skills, these are indispensable in their engineering practice. Moreover, programming, especially in the Python programming language, is often already interwoven in the various theoretical and practical subjects, requiring at least a basic knowledge. Commissioned by the Executive Board of TU Delft, the Digital Skills team has been developing several modules to teach students how to program in Python. Although Python can be taught with several means, Jupyter Notebooks have become immensely popular, almost main stream. The original materials developed by the Digital Skills teams consist of 4 such [Jupyter notebooks](#) (or modules).

Currently new initiatives for integrating programming education into different curricula and developing learning materials that can be easily adapted and customized for the integration into different curricula are

being developed. As almost each engineering education programme requires to learn to program, it is beneficial to collaborate between educational programmes and even faculties.

In Delft many materials by Pols and [Woudenberg](#) are already freely available. To accommodate teachers, the information on the digital skills website will be extended. The idea is to place the collection of open teaching materials on programming on the digital skills website. This will benefit the teachers in Delft at first as available teaching materials can be adopted and/or adapted. Once a tentative list of materials is available, we will reach out so that a large community of engineering educators may benefit from these as well.

UNCAGE Chatbots for Goal-Setting Support

With the growing importance of teamwork in higher education, effective communication, and goal congruence have become vital in improving the effectiveness of student teamwork and collaboration. To this end, within the [UNCAGE project](#), Dr Ujwal Gadiraju from TUD designed and implemented a novel system that combines a goal-setting chatbot and an effort visualizer to facilitate effective collaboration in student teams.

The chatbot guides students to set specific (SMART) collaborative goals. At the same time, the effort visualizer displays each member's contribution, thus increasing accountability among team members and facilitating greater participation. We carried out a controlled study across

four experimental conditions in a collaborative creative writing task (N=84) to evaluate the benefits of the collaborative goal-setting chatbot and the effort visualizer.

Our results showed that neither the chatbot nor the effort visualizer alone positively impacted student engagement and collaboration. However, when using the chatbot and effort visualizer in combination, we found evidence that suggests improved student engagement and collaboration. This has useful implications for the design of AI tools to support learning activities in education.

Furthermore, to support collaborative goal-setting using conversational agents, we created an open-source agent called 'GoalKeeper' which can be integrated into Slack workspaces. Inspired by initiatives in workplace learning, we explored goal-setting practices in crowdsourcing marketplaces and the role of conversational agent representations on user engagement and performance. We explored the potential of leveraging the 'wisdom of crowds' to power conversational agents in different contexts such as information retrieval or supporting stress management, while analyzing the tolerance that users have for delays in such real-time contexts.

“Quantum programming, generative AI, applications like computational fluid dynamics shape the digital landscape and demands for future skills of the digitally literate engineer.”



Collaboration with Groningen University: engineering in a comprehensive university

THE Groningen Faculty of Science and Engineering (FSE) is responsible for over 1,000 courses given by 300+ university teachers. FSE sees that higher (engineering) education in Groningen is at a crossroads position, calling for many changes and considerations, among which: anticipating AI, connecting to contemporary study behaviour, creating a makerspace community at RUG, implementing the academic career track with emphasis on teaching and learning, and launching the institutional Centre for Learning and Teaching.

FSE has potential and momentum to catalyze education innovation and to collaborate with 4TU.CEE. Dr Gerald Jonker has been appointed as contact person for the RUG and has joined the CEE board meetings regularly. Groningen Professor Lucy Avraamidou has been appointed as member of CEE's Advisory Board.

The first concrete collaboration and/or experience exchange initiatives have been within the CEE portfolios of Teaching Excellence (Sectorplan project), Challenge Based Learning, including collaborative learning (participation in CBL webinars), and ICT-Enhanced Engineering

Education (post-Covid teaching). For the next strategic CEE period '26-'29 we agreed that RUG via Gerald Jonker and Lucy Avraamidou will contribute to the development (in 2024 and 2025) of our new Strategic Agenda.

FSE has a project steering committee that initiates and monitors faculty-wide projects on teaching and learning.

- International classroom: this project focuses on the benchmarking of the current state of affairs of international classroom concepts and principles, and their current level of implementation among FSE university teachers and students.
- Graduate attributes: this project focuses on a well-motivated selection and precise description of graduate attributes and their proper embedding in the different curriculums.



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- Deployment of Teaching Assistants (TA): this project focuses on improving the recruitment and selection process of TAs, including the evaluation of the TA training.
- Review course evaluations: this project focuses on the development of a (more) uniform system of taking course unit evaluations and follow-up activities.
- Increasing student influx of teacher training ('docentenopleiding') programmes: this project focuses on developing and implementing measures to stimulate student influx (and outflux) in the teaching training programmes chemistry, physics, mathematics, and computer science.
- FSE Assessment policy: this project focuses on the (further) alignment and implementation of the RUG assessment policies at FSE.



3 | Engineer of the Future Responsible Engineer

The third theme focuses on the ethical and sustainability mindsets and competences of engineers. Society asks for responsible engineers who can address moral issues and questions when developing their innovative technologies; both in more traditional engineering field (e.g. civil or mechanical engineering, and many others) and in relatively new, but rapidly developing fields (e.g. biomedical engineering, quantum, AI, and many more).

Good value-based design and engineering should advance society at large. Therefore, engineers need to be educated on how to ex-ante evaluate who might benefit (or not) from their artefacts and whether their artefacts contribute to a more sustainable world. For this theme 4TU.CEE collaborates with 4TU.Ethics.

PhD project - Sustainable and responsible engineer

Environmental engineering education is complex as environmental problems are embedded within a myriad of societal structures. Because of this, normativity, that is questions on what ought to be, is a central part of environmental education. Teaching about environmental problems is teaching from a certain societal, political, and ethical stance. To make implicit normative assumptions in curricula explicit, the first output of this PhD project by Thijs Loonstra (WUR) is a 'taxonomy of environmental paradigms'. This can serve as a pedagogical tool for recognizing and reflecting critically on the normative assumptions of environmental education.

The second publication of this project is a thematic content analysis of university course guides, to understand how normative theory from the literature is reflected in higher education. The preliminary conclusions and recommendations of this project are that the different levels of description in the sciences are strongly connected when it comes to their normative presuppositions. Models of the environment from the natural sciences inform how solutions to environmental problems are approached in the social sciences. Therefore, greater interdisciplinarity and diversity in theoretical perspectives help foster the critical reflection necessary for dealing with normativity in higher education.

Transformative education for sustainability

TU Eindhoven researches how to empower its engineering students of today to contribute to a better world of tomorrow by investigating transformative education. The project Transformative Education for Sustainability, funded by 4TU.CEE, is led by transitions researcher Zahar Koretsky, who is a post-doctoral researcher at TU/e's Technology, Innovation and Society group. The project aims to identify a transformative educational vision for the university and run experiments in Eindhoven's makerspace Innovation Space.

COMET

CEE in Delft supports the development of ethics pedagogies that contribute to educating engineers who understand that technological solutions come with ethical repercussions, issues, and questions. The education innovation

and research project [COMET 3.0](#) develops, implements, tests, and evaluates innovative learning activities to stimulate high-quality engineering ethics education. It is the third stage within COMET: Comprehensive Ethics Teaching for Engineering and Design.

A dedicated team led by Dr Lavinia Marin and Dr Janna van Grunsven investigates both fundamental and practical aspects of engineering ethics teaching. The intended project outcome is a set of four exercises for students focusing on moral sensitivity, moral imagination, empathy, and anticipation. Other educators should be able to adapt those exercises to their specific course and context. Additionally, a train-the-trainer workshop will help the 4TU engineering university teachers feel more confident in teaching ethics.

Delft Sustainability Education

During the 2022-2023 academic year, an inventory of climate and sustainability education was done of TU Delft's master's, bachelor's, and minor education by Monika Roeling, under the supervision of TU Delft's sustainability coordinator Prof. Andy van den Dobbelsteen. For this, the study guide information was examined for keywords and the SDGs. This overview has been helpful as a starting point for understanding the state of the art of climate and sustainability education in Delft and setting objectives for education innovation in the future. The results of this research were presented in the [GreenDatabase](#). Students can use this platform for searching for sustainability-oriented courses.

In addition to this research, possible frameworks to further structure the implementation of sustainability in education were investigated. The '[engineering for one planet](#)' framework has been chosen and will be adapted to the TU Delft teaching context.

In the meantime, a special interest group has been set up in cooperation with the Teaching Academy to gather university teachers who would like to work more intensively with sustainable education. At the end of 2023 and in cooperation with GreenTU, an education hackathon pilot was organised where students and staff could brainstorm how sustainability could be implemented in education even more.

Teaching sustainability

Recently a new project has been approved that will focus on the embedding of the topic sustainability within the four institutions of 4TU alliance. The deliverables of this project are both practical and academic: institutional reports and a journal publication. The outcomes of the project aim to provide evidence to inform and guide professional development policy, strategies and initiatives in the partner institutions in 4TU. In addition, through the journal publication, the project will raise awareness of the needs for HEE teacher competences and offer models and frameworks that can be used by other similar institutions providing far-reaching impact in STEM and sustainability education communities.

INTERMEZZO

4TU in CDIO



CDIO (Conceive-Design-Implement-Operate) is the global platform that shares insights and discusses today's and tomorrow's engineering education. Throughout the world, about 200 universities are CDIO members, including our four Dutch universities of technology: Gommer/Poortman (UT), Lemmens/Ventura-Medina (TU/e), Van Puffelen (WUR), and Rooij (TUD) – are the 4TU CDIO institutional contact persons.

The Annual International Conference is the key event for the CDIO community where engineering educators from all over the world come together, share their knowledge and educational practices, and promote the advancement of CDIO for producing the next generation of engineers. It includes presentations of papers and posters, as well as specialized CDIO workgroup activities, engaging workshops and roundtables, and social events.

The Full Papers fall into three tracks: Advances in CDIO, CDIO Implementation, and Engineering

Education Research. The advances and implementation papers focus on engineering education innovations and activating pedagogical practices. The research papers focus on educational scientific research on engineering pedagogies. All contributions have undergone a full single-blind peer-review process to meet scholarly standards.

The 18th International CDIO Conference took place in Reykjavik, Iceland, June 12–15, 2022, hosted by the Department of Engineering at Reykjavik University. The 19th International CDIO Conference took place in Trondheim, Norway, June 26–29, 2023, hosted by the Centre for Science & Engineering Education Development at NTNU. 4TU is a well-known contributor and visitor of CDIO. Tens of 4TU colleagues share their innovation and/or research projects.

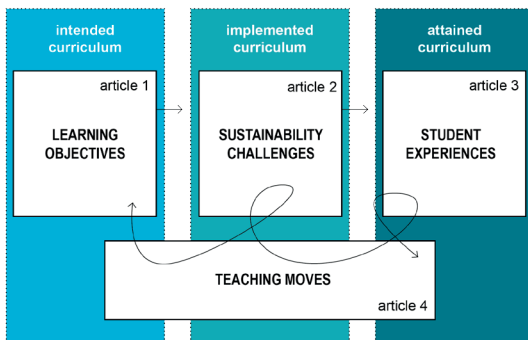
The proceedings of the conferences are among others accessible via de [CDIO publication website](#).



4 | Future of Engineering Education Challenge Based Education

The fourth theme relates to the future of engineering education and in what kinds of curricular and extracurricular learning environments we would like our students to become knowledgeable and skilful: hubs, living labs, learning ecosystems, innovation spaces, dream teams, hackathons, or more course-based forms of learning via challenges.

What identifies and characterizes challenge based learning (CBL) and/or challenge based education (CBE) in terms of typical learning activities, processes, and outcomes/effects, including assessment strategies? How do we as university stimulate and support both students and teachers to work inter- and transdisciplinarily and thus to cross boundaries?



The structure of the design-based research project on uncertainty in transdisciplinary learning in relation to the curriculum model of Van den Akker (2013)

PhD project – Transdisciplinary learning

I 27

In her PhD project, Nina Bohm investigates how students learn to deal with uncertainty while working on real-life, sustainability challenges. The project is split into four smaller studies that each take a different perspective on the transdisciplinary curriculum. For the first study, Nina spoke to transdisciplinary teachers about their aims, visions, and ideals. She compared this 'intended curriculum' to the aims in the course guides and found some interesting similarities and differences. The next three studies in the PhD project focus on 'dealing with uncertainty' as a sustainability competence. To this end, Nina worked as an embedded researcher in the Living Lab course in MSc MADE, Metropolitan Analysis, Design, and Engineering, a unique challenge based urban living lab in Amsterdam. First, Nina analyzed what kind of uncertainty could be found in the sustainability challenges in the course. Second, she interviewed students in the course about their experiences with uncertainty. The last study is a design-based investigation with teachers to develop teaching moves to better guide students through uncertainty.

Next to her PhD project, Nina is involved in several educational innovation projects within the TU Delft, such as the development of the Personal Development Weeks in the renewed bachelor curriculum at the Faculty of Architecture and the Built Environment. Nina contributes to the faculty's research on comparative assessment. Nina presented her work at several conferences, such as SEFI, CDIO, and the National CBL Conference. Nina's PhD project will be completed in 2024.

Student learning experiences: Cases of maths and physics

This TU/e project aims to support the mathematics and physics engineering disciplines to adapt their education in terms of CBE. To do so, we listen to the instructors' and designers' voices and most importantly, to the students' voices concerning their learning experiences in CBE courses, including their benefits and needs.

As there is experimentation with CBE from teachers in specific courses in mathematics and physics, we want to know the experiences, in particular student experiences, in these innovative learning environments.

“Hubs, living labs, learning ecosystems, innovation spaces, dream teams, hackathons, course-based forms of learning via challenges, and other kinds of curricular and extracurricular learning environments are studied for the purpose of developing future engineering education.”

Therefore, we address three sub-themes:

1. We investigate the **intended curriculum** of CBE courses, situated in the general higher engineering education scene at TU/e. Deans and policy makers of TU/e provide context data that surround the cases.
2. We address the **enacted curriculum**; how discipline-educated university teachers experience and develop their roles; and how they develop new interactions with students.
3. We address the **experienced curriculum** at student level; how students learn in such innovative learning environments, in particular concerning their use of resources and the support they (perceive to) need for their learning, what kinds of skills and capacities they develop, and which work forms (they perceive) work best for them.

In the study we use a case study approach and mixed methods within the cases, to investigate students' learning experiences in three different TU/e courses and environments: (1) a course for mathematics and/or physics students in an early stage of their Bachelor programmes; (2) a course at the end of the Bachelor programme (the Innovation Space Bachelor End Project); (3) a Master course for mathematics students, the mathematics “Modelling week”.

From JIP experiment to 'new' Delft culture

At TU Delft, CEE was the initiator of the Joint Interdisciplinary Project master's elective (15EC) in the first quarter of the second year. For several years now, this has been a huge success with hundreds of students coming from various master's degree programmes studying socio-technical challenges in teams and collaborating with societal and industrial stakeholders from practice. It has been so successful that TU Delft has started to implement space for all master students and all master programmes in this fifth master's quarter for inter- and transdisciplinary modules. Faculties and interdisciplinary teaching teams across faculties have been invited to develop a larger set of courses.

At the same time, CEE took up this acceleration to support a project that aims to create a CBL community in Delft and to exchange CBL experiences and expertise, addressing questions like: What cognitive processes are central to synthesis and integration? What transversal skills are needed? What didactic tools and work formats best help students experience this integration process? What professional development training or support should teachers receive to facilitate, guide and evaluate the students' integration processes in these varied contexts? Which epistemological knowledge systems are we dealing with, and how should the different norms and values encountered in these diverse situations be overcome?

Learning together

Learning Together in CBL is a TU/e research project aimed at studying the epistemological perspectives of students, teachers, and (societal and industrial) stakeholders in a collaborative process of challenge based learning.

Epistemic perspectives encompass views on the nature of knowledge, the reliability of sources of information, the role of evidence and experimentation, and the level of certainty or uncertainty inherent in a given body of knowledge. Hence, epistemic perspectives form the basis for the design of any learning environment as they influence the learning objectives, assessment, and teaching techniques to be followed. But they become increasingly important in our current times where the rise of technologies like generative AI is pushing educators to rapidly adapt their curriculums to correspond to needed knowledge and skills.

In this project, we engage with the students to facilitate reflection on their educational experiences, and with teachers to support them in the redesign of their CBL courses.

Healthy challenging design education

Design education is a valuable mode of CBL at TU Delft and teaching physical design skills has long been the main building block of the bachelor curriculums at the faculties of Industrial Design Engineering and Architecture & the Built Environment. Undergraduate students achieve high-level (design) competencies during their study time at TU Delft. But design education too often goes together with over-aroused students and (over) ambitious teachers, leading to higher levels of student stress. This results in (the threat of) underperforming students, increased levels of student dropouts, and increased levels of student burnout.

It is easier said than done to (re)develop healthy challenging design education. Stress is something that works differently for different people, and some levels of stress are needed to perform well. The most important thing might be to have a 'tool' to talk about this sensitive topic with and among design students, design tutors, and design project coordinators.

The three models that were co-created in this project [Healthy Challenging Design Education](#) consist of [i] a view on the characteristics of design education from a well-being point of view, [ii] a Spheres of Influence in Design Education model, and [iii] a model that gives students and staff a way to discuss, give constructive meaning to, and make decisions in stressful circumstances.

The project among others resulted in a book that not only presents

these models, but also a large set of experiences in the format of short stories written by bachelor design students, teachers, and study advisors. Additionally, the models are used to position those stories to show how students and teachers could go forward more or less constructively in stressful situations. This book is now used in the Delft bachelor design education practice; both for students and teachers.

Twente CBL fellows

The first [Teaching & Learning Fellowships](#), made possible by 4TU.CEE at the UT, have been concluded with a CBL symposium in October 2023. The programme started in 2021, with the aim of stimulating staff in pioneering in educational R&D activities to both advance their own professional development but also help improve education. The first T&L Fellows, Tracy Craig, Janneke Ettema, Raymond Loohuis, Robin de Graaf, Anna Bos-Nehles, and Léon Olde Scholtenhuis completed their fellowship with a concluding CBL symposium, for a large audience of scientific staff, policy-makers, educational experts and students. Through dedicated teamwork, they implemented CBL at the course, programme and inter-programme level.

Researching and sharing experiences from practice among each other and with others was central throughout their fellowship. They focused on CBL design principles and what it takes to work on these levels to integrate the CBL framework in education. They organised and participated in conferences and workshops (including some of the 4TU.CEE CBL webinars), won grants

and awards, and gained valuable insights in CBL implementation at the UT. The rector received from the fellows' 'fifteen commandments' of CBL capturing everything the fellows learnt in the past two years in a condensed way. These are categorized in recommendations for students, teachers, educational management and society. The 'Challenge-up' tool was also presented at the symposium to support teaching in taking steps towards more intensive CBL modules.

“We facilitated webinars that focussed on educational initiatives, research projects, tools to set up challenge based learning, a workshop on how to assess in CBL and a round table discussion on how to set up CBL in which students and external partners co-learn.”

CBL webinars

In 2022 and 2023 CEE followed up on the in 2021 started [webinar series on Challenge Based Learning](#). Four webinars per year were organised and visited by teachers, researchers, and educational advisers of all four universities. The webinars discussed the student perspective, the university teacher perspective, and the roles that external stakeholders fulfil or want to fulfil.



We facilitated webinars that focussed on educational initiatives, research projects, tools to set up challenge based learning, a workshop on how to assess in CBL and we wrapped up in 2023 with a round table discussion on how to set up CBL in which students and external partners (companies, policy, costumers, NGO's etc) co-learn. This roundtable showed much enthusiasm from students, teachers, and external partners and interesting perspectives on how to make CBL more meaningful to all.

The CBL webinars offered an effective opportunity to share but also to critically discuss some challenges and opportunities between initiatives at our institutions. In 2024, we will continue organising CBL webinars in which we start to look beyond the 4TU. The session in January will be hosted by our new partner (RUG), in March we have a guest speaker from UCL and in May we will be discussing CBL practice and research from Aalborg University.

Institutional education innovation calls

Next to national education innovation calls such as Comenius or SoTL (Scholarship of Teaching and Learning), our institutes also promote education innovation via internal calls.

WUR: Call for Education Development & Innovation

In 2023, WUR's Education Innovation Board and the staff department Education & Student Affairs (ESA) organised the Call for Education Innovation for the first time in years. The call has been developed to encourage lecturers and others to keep on developing their education up to the most recent insights and share their experiences within and outside the university.

Innovations should contribute to an improved learning process for students and a positive work experience for lecturers and fit within the education philosophy of WUR. The call was not just presented as a possibility for funding, but rather as an invitation to discuss ideas and dilemmas.

More specifically to:

- inform on available support programmes and subsidies;
- refer colleagues based on their problem statement / initial ideas for development or innovation;
- advise on the further development and realisation of initial ideas, both regarding educational support and financial resources.

In the spring and autumn together more than 60 initial ideas have been submitted and 35 ideas have been worked out in final proposals after discussion and support by ESA. In total 15 proposals have been granted and 3 lecturers received an incentive grant for an edtech implementation. The focus of 2023's call was on student-centred learning with specific attention to assessment, following the principles of WUR's new assessment policy.

“Innovations should contribute to an improved learning process for students and a positive work experience for lecturers.” - WUR

Granted proposals concern:

- development of trajectories for skills development and boundary crossing and the (programmatic) assessment of these skills;
- experiments with AI in education;
- applications of virtual, augmented and extended reality;
- embedding of real-life and challenge based learning in existing courses, using different strategies and teaching methods;
- development of a longitudinal career preparation programme;
- experiments with the development of knowledge platforms facilitating the heterogeneous backgrounds of course participants;
- development of a general framework for scientific computing.

TUD: Calls for Education Fellows, Open Educational Resources, IDEE

The TU Delft Education Fellowship is a two-year grant to carry out an innovative educational project. The Fellowship recognises and appreciates the efforts of university teachers for educational innovation and boosts the impact on educational reform and development. The Dean of each faculty nominates each year a maximum of two potential Fellows. The Assessment Committee consists of the Vice-Rector Magnificus/Vice President Education, Academic Director of the Teaching Academy, a Dean, a Director of Education and an appointed Education Fellow.

Each year TU Delft appoints four new Education Fellows. Since 2016, 31 Education Fellows have started their educational fellow project. Education Fellows perform an ambassador role within the university. They encourage other lecturers to also be or get actively involved in educational innovation. To this end, Fellows will also be actively involved in the Teaching Academy and the TU Delft Education Day.

“Open Education brings together educational innovations such as the increasing role of digital technologies in education and the increasing of students’ autonomy in educational processes, and couples these with values of diversity and inclusion.” - TU Delft

The TU Delft Open Science programme puts a strong emphasis on developing Open Education as one of its main project pillars. Open education brings together educational innovations such as the increasing role of digital technologies in education, blended learning, and the increasing of students’ autonomy in educational processes, and couples these with values of diversity and inclusion. Since 2022, all TU Delft teaching staff are encouraged to submit a proposal for Open Education projects within the Open Education Stimulation Fund for funding a project term of a maximum of 1 year.

The Innovation in Delft Engineering Education (IDEE) programme addresses institutional challenges in providing student-centric, world-class education. IDEE offers opportunities for scientific staff members to work on those TU-wide challenges in thematic teams. Teams design, investigate, implement, monitor, and evaluate innovations in TUD’s engineering education.

IDEE aims to have up to five teams working on different topics at any given time, with each team having five years to complete

their work. Since September 2023, the first three teams have started focusing on [i] students taking responsibility for their learning, [ii] retention of knowledge and skills, and [iii] future engineering skills.

Besides the scientific staff members recruited in an open call (in-kind contribution from departments), the teams also include an additionally funded postdoctoral researcher, an additionally funded PhD candidate, and a learning developer from the department of Teaching & Learning Services (in-kind contribution). The quality of the research programme in IDEE is assured by its recently appointed scientific director Professor Kristina Edström.

TU/e: Calls for Education Innovation

The field and the role of engineers are becoming more relevant due to the need to solve emerging societal challenges. Transforming educational paradigms from teaching to learning with emphasis on student-centered pedagogies is important to prepare the new generations of engineers and scientists to meet these challenges.

We know that TU/e has a proficient academic staff with an innovative mindset regarding education. Therefore, there are several funds available, to enable educational innovation and improvement.

The 4TU.CEE at TU/e collaborates with four other TU/e innovation programmes: Challenge Based Learning programme, Boost! Edtech programme and Boost! Learning Analytics programme. Together, an annual

call for proposals is sent out. Submitted proposals are reviewed and matched to a programme. Sometimes programmes co-fund projects.

The focus for the 4TU.CEE Innovation Fund at TU/e is on educational research proposals. For several years the 4TU.CEE Innovation Fund at TU/e has been encouraging teachers to innovate their education with small-scale experiments and research. Many projects have been successful and led to promising innovative practices. Ongoing and finalized projects are reported on the Innovation Map.

“Transforming educational paradigms from teaching to learning with emphasis on student-centered pedagogies is important to prepare new generations of engineers and scientists to meet emerging societal challenges.”
– TU Eindhoven

Current projects are:

- Learning together in Challenge Based Learning
- Transformative Education for Sustainability at TU/e
- AI in Education
- Ethical guidelines for responsible use of AI generative tools in engineering education
- Embracing the future: the use of ChatGPT in science teacher education

“The UT Teaching Community connects professional development activities and promotes the feeling of a UT community among teachers, emphasizing the importance of education and advancing teaching excellence.” - UT

UT: Calls for Education Innovation

At the University of Twente, Challenge Based Learning and Teaching Excellence have a major focus in the innovation calls. In 2021 a pilot with Teaching & Learning Fellows started. Goal of the Teaching & Learning Fellows programme is to stimulate staff to pioneer in educational R&D activities that can both advance their own professional development and also help improve their teaching regarding aspects that are on the educational agenda of the UT.

The evaluation of the first cohort (CBL) and second cohort (Digitalization) has led to the decision to continue this programme (see also Chapter 4, Twente CBL Fellows). In January 2024, the third cohort started, with again seven T&L fellows who work on addressing an educational problem/ambition in an evidence-informed way.

T&L fellows are increasingly encouraged to also involve other colleagues (at UT and other 4TUs) in their projects. Fellow candidates are nominated by their Faculty board, in close

communication with their direct supervisors and CEE.

Moreover, resulting from the broader ‘Action cluster Recognizing & Rewarding Teaching’ (R&R), the UT Teaching Community (UT TC) has started working on a model to further advance 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, and to promote the feeling of a UT community among teachers, emphasizing the importance of education. What is more, the aim is to make a concrete connection to the R&R teaching framework in terms of performance criteria and career paths.

Apart from the more individual opportunities for (teaching) staff to submit innovation project proposals, TC community inspiration lunch meetings are now organised 3-4 times per year. Each lunch meeting is planned starting with an inspirational presentation about a theme relating to student and teachers’ need in terms of student learning and/or wellbeing.

Additionally, participants have the opportunity to discuss possibilities to work on an educational and/or student wellbeing problems together.

To make these ideas concrete, participants are encouraged to respond to the call to work on this idea together via an innovation project, reviewed and co-funded by CEE. Working together among staff from different faculties and possibly UT support units is strongly encouraged.

Current and recently completed project UT-CEE examples are:

- Teaching & Learning Fellows (5 faculty fellows, 2 senior fellows projects): theme CBL
- Teaching & Learning Fellows (5 faculty fellows, 2 senior fellows projects): theme Digitalization
- Teaching & Learning Fellows (5 faculty fellows, 2 senior fellows projects): theme Building inclusive communities
- Learning analytics project Bridging the gap
- Establishing Heatquiz
- Challenge up
- Digitizing Engineering Sciences



5 | Future of Engineering Education

ICT-Enhanced Engineering Education

This fifth theme is about ICT-enhanced teaching and learning: flexible and personal learning paths of learners, blended, hybrid, and/or online solutions, especially for engineering-specific activities such as lab education, design education, excursions, collaboration in augmented or virtual reality. This subject got an acceleration during and after the COVID-19 pandemic. It should not be analysed separately but rather seen in interaction with many developments for future education.

4TU Learning Analytics community

Learning Analytics research shows a high potential for enhancing teaching practices as well as learning in multiple ways from deeper understanding and reflection, personalized learning support as also efficiency and self-regulation. Nevertheless several factors have been constraining the adoption of LA in higher education especially in Europe and also the Netherlands.

In a joint community the 4TU.CEE aims to tackle the big challenges in scaling up LA in Engineering Education from a) developing a shared basis for organisational policy b) scalable and easy implementation in Engineering Education courses with clear benefits c) developing a shared culture for data driven teaching and learning embracing LA at the core. The initiative starts from successful implementation in the 4TU context and disseminates these cases to the 4TU partners and engages in a shared upscaling of these practices towards a sustainable and effective data driven education model of the future. In 2024, CEE

organises a series of workshops for collecting and dissemination of the success stories and initiation of collaboration between the partners.

PhD project – Collaborative Learning

Engineers are increasingly required to work on complex design projects in which successful problem-solving requires the collaborative efforts of a multidisciplinary team. To prepare engineering students for these professional practices, educational institutions increasingly implement engineering design activities in which students can develop new collaborative design practices, such as concurrent design. Still, it was found that students are often hesitant to adopt new collaborative practices and tools and stick to ways of working they already know.

In the current project by TU Delft PhD candidate Gitte van Helden, we aim to develop educational design principles to foster the development of students' new collaborative practices and tools. Specifically, we investigate how the tools available in the Collaborative Design Lab (CDL) can be integrated into courses to teach agile project management and concurrent engineering practices. In the upcoming years, we will use a design-based research approach to iteratively develop a course in the CDL, while simultaneously formulating theory-informed design principles to foster students' development of new practices and tool use.

PhD project – Click2Empower

This TU/e PhD project by Ran Zhang focuses on Learning Analytics for the assessment and personalized support of student well-being, student resilience, and learning outcomes. The project produces intervention tools, predictive models, and insights that facilitate unobtrusive assessments of students' well-being (potentially in all TU/e Canvas courses) in an automatic and efficient way and empowerment of students to maintain or improve their academic resilience and learning outcomes in a personalized way, given indicators of poor or declining student well-being.

Through the extension of ICT-enhanced education, the project makes an important contribution to realizing one of the educational goals of the TU/e education vision 2030. Of particular interest is the issue of whether and to what extent assessment and support of student well-being and resilience need to be tailored to “traditional” engineering versus other students (e.g., Psychology & Technology students at IE&IS). [Click through](#) & empower yourself!

Paella

The TU/e [PAELLA](#) project on Personalized Activation in Education Leveraging Learning Analytics develops and tests a new learning design in different Bachelor courses. Within these courses, we use click-stream data from the Learning Management System (LMS) to push forward personalized

“Learning Analytics has a high potential for enhancing teaching practices as well as learning experiences, Click2Empower at TU/e focuses on LA for the assessment and personalized support of student well-being, student resilience, and learning outcomes.”

feedback and formative testing in the Bachelor programme. For selected students with a backlog in their online learning, we offer appropriate (mindset) interventions that stimulate students' self-regulation of learning.

For this, we address the following questions:

- How can we use the LMS data in a scalable way to differentiate between students who are on track and those who lag in their learning process?
- How can we design and apply personalized interventions in LMSs that activate students and stimulate them to better self-regulate their learning in an engineering context without increasing the teachers' workload?
- How can we track students so that students' privacy is guaranteed and that they do not feel threatened during online and blended learning?

Several detailed learning points for teachers emerged that we summarize in the [reports](#) on our website. On a more general level, the use of Learning Analytics-based interventions requires a well-coordinated and intensive

collaboration between the ICT department on the one hand and the teachers and researchers on the other hand. Teachers must go through several steps to prepare, execute, and evaluate a Learning Analytics-based online intervention. These include:

1. Take into account privacy regulations and the students' perspectives
2. (If necessary) Re-design the course to have a data-rich online environment
3. Scripting and pre-processing of clickstream data
4. Identification of the intervention's target group
5. Execution of (earlier prepared) online intervention
6. Evaluation of effects

CMODE implementation

4TU.CEE at TU/e supports a sequence of projects related to the course CMODE: Constructing knowledge based on modular On-demand Digital Education. The goal of the CMODE projects is to develop a course design strategy based on three ingredients needed for (deep) learning: boundaries (context), resources, and a question that triggers imagination.

The follow-up project CMODE-UP uses the results of CMODE and creates evidence-based design principles for teachers to design their courses in engineering education with online modules. A teacher guide was also created to assist teachers in their design decisions. The results from a teacher workshop have been combined with the results from a literature review. CMODE-UP has resulted in two concrete products.

The first product contains six design principles for the teachers to consider as they design their course with a modular approach: 1) Course content: analyze learners, resources, and course learning outcomes, 2) Module category, 3) Weekly alignment, 4) Module development, 5) Implementation, and 6) Course evaluation. The second product is a teacher guide that further supports teachers in designing courses by showing them selected illustrative articles. This teacher guide is a practical source to illustrate how the design principles have been implemented elsewhere and give examples of how and why a teacher might choose from different design options.

With CMODE-UP: Implementation, the researchers worked on the iteration and validation of both products, through a testing of the design principles at TU/e engineering courses at a short teacher workshop and a descriptive review of 20 published papers.

AID-E and Data Enhanced Education

In November 2023, the AI in Education Hackathon was organised at the UT, initiated by the AI and Data in Education (AID-E) network. It was made possible by 4TU.CEE and Research Institute DSI, and organised by Pro-U in collaboration with Pre-U, the BMS Faculty, and the EEMCS faculty. After last year's successful Hackathon, this year almost double the number of teams participated from different educational institutions and organisations. After the opening introduction by Kim Schildkamp (UT, ELAN), Talitha Visser (UT, ELAN) presented last year's winning team's 3rd grade Chemistry balancing (reaction) equations proof of concept. Then Maurice van Keulen

(UT, EEMCS) warned for the threats to AI. On the second and third day, teams could work on their proof of concept supported by 'jedi's', alternated with further inspiration sessions. Bertine van Deyzen (SURF) talked about demystifying and defining AI. NOLAI director Inge Molenaar introduced the national Education lab AI, and talked about the 6 levels of automation model and upscaling NOLAI.

“The AI in Education Hackathon, organised at the UT, brought together different educational institutions and organisations and addressed topics as demystifying and defining AI, as well as threats and applications of AI in education.”

In the final presentations, themes varied from formative feedback on bachelor theses to padel training. The jury consisted of Tjeerd Hans Terpstra - CITO, Bernard Veldkamp - UT, Bertine van Deyzen - SURF, Esther Ventura-Medina - 4TU.CEE and TU/e, JaapJan Vroom - MBO-raad and NPuls, and Bram Enning - HS Leiden and NPuls. The winners: the University of Bremen-UT team with 'Automated AI-based Feedback on Educational Videos for Teachers and Learners', and the Saxion University of Applied Sciences team with their Virtual study coach named sAxI. They were awarded the prize of further exploration with experts.

100 days of... Data for Learning

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For the past decades, the role of data has been ever growing in almost all fields - learning (and education) not excluded. But what is meant by 'Data for Learning'? What data is available at TU Delft to support teaching and learning? In what way is it being used? For what purpose - and with which impact? And what are the challenges involved? These have been the questions which motivated the team of '100 Days of... Data for Learning' to shape a joint programme with 4TU.CEE, LDE-CEL, the TU Delft Extension School, Teaching and Learning Services, and the Teaching Academy.

In the '100 Days of... Data for Learning' the team has organised peer exchange among scientific staff and educational support, students, and lecturers. The participants held journal clubs, invited science speaker sessions, and a hackathon event to understand the role and potential of data to support teaching and learning. In detail this included twelve science speaker sessions in which a variety of topics has been presented and discussed about current applications of data in teaching and learning support as also fields of tension and challenges.

“ICT-enhanced teaching and learning theme is all about flexible and personal learning paths of learners, blended, hybrid, online solutions, and collaboration in augmented or virtual reality. We view these ICT enhancements broadly, in interaction with many developments for future education.”

Learning Analytics Eindhoven seminars

In 2023, 4TU.CEE at TU/e together with the TU/e Boost! programme organised a trilogy of hybrid lunch sessions on several projects related to Learning Analytics (LA) and AI. The sessions were supported by the Academy for Learning and Teaching at TU/e.

The aim was to share knowledge and network among the 4TU colleagues on this topic. All sessions were very successful and interactive with 50% of the participants on campus and 50% online. In the first session, some background information on LA was given and a presentation on self-regulated learning and LA was followed by a presentation of a pilot where LA was used to forecast student learning outcomes.

The second session highlighted two pilots of personalized learning. Ranging from offering students different content streams within

a course based on their background and preferences (chameleon project) to personalized interventions based on canvas data (Paella). The presentations showcased the power of LA and the potential LA has for the improvement of student learning outcomes. A third session highlighted three ongoing projects related to ChatGPT in TU/e education.

In 2024, a half-day workshop will be organised on the challenges and opportunities of LA in higher education institutes, on both a national level (at TU/e) as well as on an international level (LAK conference, Kyoto) to be followed up by a webinar where the conference insights will be shared.

Anticipating the new educational challenges for universities

A literature review by 4TU.CEE WUR has led to the draft article: “Education Design for New Educational Challenges of Universities”. It goes without saying that many developments influence the future of the higher education landscape. But without any doubt, ICT-enhanced teaching and learning plays a vital role to meet the future needs of students and university teachers.

The draft article is a starting point for writing the new vision for Education at Wageningen University and will also be input for the development of the new 4TU.CEE strategic plan 2026-2029. When published, the article will be available for general use via our CEE [Innovation Map](#).

INTERMEZZO

New education design for universities using pandemic experiences

ALL 4TUs presented research on the post-Covid theme in a lively CEE webinar, 3 November 2022. It provided insight into the effects of Covid forced emergency remote teaching (ERT) and the transition out of limitations. The experiences lead to conclusions on how to proceed in future years.

Virus variants might cause new outbreaks; we should stay prepared for remote teaching. This requires focusing on well-being, a sense of connectedness of students and staff, and having online versions of courses available. Also, it is time to integrate the online courses made for ERT into the blended learning curriculum for less restricted times.

Guidelines

- Students differ in preferences towards online and teaching and learning activities (TLAs) in general. A carefully designed mix of TLAs is needed to activate most students. It is not simply flipping one kind of TLA for another.
- The combination of synchronous and asynchronous TLAs needs more design time than we had at the ERT beginning.
- Create (partial) online ERT alternatives for lab education, excursions and assessment.
- Continue in the direction of student-centered learning and flexible learning paths, but carefully! as this might cause a higher workload for teachers.
- Monitor change in learning; use the experience with learning analytics.
- Campus education remains essential and helps with a sense of connectedness.

6 | Future of Engineering Education Teaching Excellence

The sixth and final theme is oriented toward the university teachers, teaching teams, teaching expertise, and teaching quality. Continuous professional development and diversification of career pathways are intensively discussed within the Netherlands and 4TU. Important questions pop up around topics such as evidencing teaching achievements, establishing good quality indicators for engineering teaching quality, developing teaching and learning centres, and investigating teacher learning during educational innovations.

Also with the new pedagogical formats (see Theme 4), new or different roles of university teachers get more attention: e.g. teachers as coaches and teachers as designers of blended learning environments.

Teaching Culture

4TU has continued to contribute intensively to institutional, national, and international discussions on advancing the academic teaching culture. CEE is a partner and sponsor of the international Teaching Culture Survey and the Advancing Teaching Culture network led by Dr Ruth Graham.

This resulted in many activities and results, among which:

The Teaching Culture Survey 2022: The TCS results show that a vast majority of our 4TU communities would like education to be of greater importance in career advancement and promotion to full professor. However, the communities' perception is that this does not yet happen

(quickly) enough and our colleagues have little confidence in our leadership. The greatest concern and scepticism are found among mid-career academics, especially Assistant and Associate Professors.

Advancing Teaching Culture meeting: The international meeting in June 2022 in Amsterdam touched upon the process of changing institutional reward and recognition systems for teaching: approaches to supporting institutional change, career pathways, professional development systems, annual appraisal approaches, mentorship systems, funding allocation models, embedding systems to support diversity, equity and inclusions, and the value of educational leadership for change. Participants shared their insights into the change process, including the challenges of changing academic cultures and aligning national frameworks.

Advice for our rectors: In order to address the issues raised in the TCS, and also at the request of the 4TU rectors, the 4TU.CEE has drawn up the advice: "Room for everyone's educational talents". It consists of six recommendations and many concrete possible actions for more visible success in the workplace in recognizing and rewarding university teaching, teaching quality, and educational career paths within the 4TUs.

Sectorplan project - Teaching Quality and Educational Career Paths

This national Sectorplan project on Teaching Quality and Educational Careers takes a close look from a beta, technology, and engineering

perspective at the national 'Recognition and Rewards' programme, which strives for diversified careers within all Dutch universities. More specifically, the project aims to distinguish whether there are engineering education-specific indicators for assessing and/or advancing academic career frameworks, pedagogical competence development, and institutional professional development programmes.

During the project (2021-2024) frameworks, tools, inspiration, and good practices are shared among participating universities via the focus group ('klankbordgroep'). The inventories, workshops and discussions will trickle down in a final publication, a book full of inspiring practices, projects, and people, and a 2024 closing event organised by 4TU.CEE.

PhD project – Collaborative course design

Rike Bron defended her PhD thesis [Collaborative course design in higher education - a team learning perspective](#) successfully on [Friday 4 November 2022](#), University of Twente. Her supervision team consisted of Prof. M.D. Endedijk and Prof. B.P. Veldkamp.

Emerging teaching methods in higher education, such as problem-, and challenge based learning require more collaboration from university teachers when designing and teaching their education. The shift towards teamwork can be challenging for them, however. In this dissertation, the collaborative course design process of university teachers was explored from a team learning perspective.

PhD project – Education Innovation Evaluation

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There are numerous innovation initiatives taking place within the 4TU to equip our students with the skills needed to meet the demands of the job market of the future and society at large. This PhD project aims to introduce a coherent planning and evaluation strategy to ensure the sustainability and resilience of our innovation initiatives. Therefore, the goal is to develop a framework that can be used by university teachers, course coordinators, and teaching teams for evaluating innovations during the different phases of planning, designing, implementing, and re-running.

This framework is developed and tested in collaboration with and/or with input from 4TU colleagues, university teachers, education advisors, educational researchers, and learning developers. In 2023, TU Delft PhD candidate Erna Engelbrecht got her 1st year 'Go' for continuing the project.

PhD project – University Teaching Qualification

This [PhD project](#), conducted by Marloes Vreekamp, investigates teacher learning and its learning outcomes using the various outcome domains of the Interconnected Growth Model by Clark & Hollingsworth in the context of the University Teaching Qualification programmes. The study involves a systematic literature review, a survey study conducted with teachers in programmes in the 4TU, and it follows several UTQ candidates longitudinally.

The literature review has recently been finished and was published in an international peer-reviewed journal. Its results show that various characteristics of UTQ programmes are important for successful learning outcomes, in particular sufficient length, collaboration activities with other teachers/candidates, a multidisciplinary setup of the programme and voluntary participation.

Currently, survey data have been collected at the 4TU and data are being analysed. First results suggest that exchange of information and experiences forms the basis for further collaboration activities within the UTQ and more learning outcomes, also on the teaching practice, student and organisational level. In 2024, further data collection will take place and several publications will be worked on.

Teachers2Learn

The Teachers2Learn project is a consortium project with 22 universities in the Netherlands, headed by TU/e (Jan Vermunt) and sponsored with a grant from the Netherlands Organisation for Scientific Research (NWO), in which the learning of university teachers in the context of educational innovation is investigated. The 4TU.CEE plays a major role in the project. The project has resulted in literature review (under submission), an accepted journal article on a review of 32 cases, and currently the project investigates mechanisms of teacher learning and factors supporting or limiting teacher learning in-depth in a series of cases and interventions.

The project has resulted in several publications and conference presentations, and organised a symposium in 2022. In 2024, the project will end and will organise another symposium. First results of the project suggest different types of interplay between educational innovations, university support, and teacher learning, for example via theme-related innovations, via open grants or via professional development.

Eindhoven Academy of Teaching and Learning

The recently established Academy for Teaching and Learning (ALT) at TU/e has been set to provide teachers with the opportunity to develop their vision and expertise on teaching and learning and in doing this improve the quality of education.

For its first year ALT has been engaging with different partners units across TU/e and outside. A full programme of events to share practice, dilemmas and discussions as well as inspire others have been developed including joint events with 4TU.CEE. Events that disseminate results from the different projects sponsored by 4TU.CEE as part of the Innovation Fund such as the PAELLA project and the series of events on Learning Analytics are some of the joint events between 4TU.CEE and ALT.

Twente Teaching Community

The UT Teaching Community was established to help UT teachers connect, contribute to coherence in teaching innovation initiatives, and to support further evidence-informed teaching innovation. 4TU.CEE at the UT is committed to help develop this idea further in collaboration with the Centre of Expertise in Learning and Teaching at UT. The Teaching Community is co-funded by the 4TU.CEE. In 2022, we have started with offering inspirational lunch meetings on teaching themes. In these lunch meetings, we aim to support sharing ideas, experiences, and inspiration.

Teachers who are inspired to work together on a teaching innovation idea, are welcome to apply for an innovation project to support them with this. There is room for 3-4 projects per year, co-funded by 4TU.CEE. Calls for such projects are announced in the inspiration lunch meetings and via the UT TC website. So far an application in the area of learning analytics, with a collaboration of multiple faculties and services has been granted (and completed successfully), and new responses have been obtained on a Teaching Community call about student self-regulated learning. Moreover, a [discussion meeting on R&R](#) was organised, because of the importance of developing R&R policy parallel to providing opportunities for inspiration and further professional development.

“Evidencing teaching achievements, establishing good quality indicators for engineering teaching quality, developing teaching and learning centres, and investigating teacher learning during educational innovations are central to the theme of Teaching Excellence.”

Delft Teaching Community

In Delft, CEE put substantial effort in working more closely with other Delft groups that focus on education innovation and education research, among which the Teaching Academy, the Teaching and Learning Services department, the LDE Centre for Learning, the Extension School, and the department of Science Education & Communication. This has resulted in a shared yearly programme called ‘100 days of...’ where a specific education theme is further explored via a variety of activities and events. In 2023, the theme ‘reflection in engineering education’ materialized in a [white paper](#).

CEE management is also part of TU Delft’s Exchange week for Higher Education Institutions. During this three-day event in Delft, participants can see and actively experience what happens in Delft concerning education innovation, the enhancement of continuous learning, and our continuous professional development programme.

“No written word, nor spoken plea, can teach young hearts what they should be. Not all the books upon the shelves, but what the teachers are themselves.”

RUDYARD KIPLING

CEE management has been closely involved in the development of a new TUD-wide programme on Innovation in Delft Engineering Education (IDEE). The IDEE programme addresses challenges faced by TU Delft in providing student-centric, world-class education. It offers opportunities for scientific staff members to work on TU-wide educational challenges in thematic teams. Teams will design, investigate, implement, monitor, and evaluate innovations in education.

In September 2023, the first three teams have started focusing on [i] students taking responsibility for their learning process, [ii] future engineering skills, and [iii] retention of knowledge and skills. Besides the scientific staff members, the teams also include per theme a (newly appointed) postdoctoral researcher, a (newly appointed) PhD candidate, and a TUD learning developer or education advisor from the department of Teaching & Learning Services. The quality of the IDEE research programme is assured by its recently appointed scientific director professor Kristina Edström.

Start SUTQ in Wageningen and Delft

WUR and TUD have started a Senior University Teaching Qualification (SUTQ) programme. The SUTQ, or SKO in Dutch, provides experienced university teaching staff the opportunity to develop advanced teaching skills as a part of their Continuous Professional Development. An additional aim of the SUTQ is to nurture a community of leading educational innovators who have a lasting impact on the educational landscape within WUR, TUD, and beyond. The programme is designed for advanced (UTQ certified) lecturers willing to experiment, innovate, develop, evaluate, and collaborate.

SUTQ participants are working on authentic projects tackling educational challenges from their teaching practices (moving beyond their course level). By doing so they become our institutional educational ambassadors. Both SUTQ programmes put the teaching practices of the lecturers central with a lot of coaching, peer learning, intervision, and reflection.



CBL conference

THE first national conference on Challenge Based Learning on 15 June 2023 at TU/e Eindhoven was a huge success! Over 250 education and research professionals gathered to discuss CBL and its impact on educating future engineers. Prof. Ines Lopez Arteaga highlighted in her opening speech the significant role of CBL in TU/e's Bachelor College curricula, setting the tone for the conference.

Prof. Isabelle Reyman's keynote on CBL and the case of TU/e's *Innovation Space* added valuable insights into CBL in Eindhoven and its learning ecosystem.

The event featured workshops, presentations, and roundtables on course and curriculum design, student learning, and teaching and teacher learning with contributions from colleagues from all 4TUs. Field trips to the proto-zone and TU/e innovation Space were an added option.

Congratulations to the University of Twente colleagues Robin de Graaf, Adina Imanbayeva, Raymond Loohuis for winning the poster prize about their project: *Challenge Up! A digital tool facilitating the transition to CBL in existing higher education courses.*

Preparations for the next edition of the CBL conference in 2025 are already ongoing at TU/e, again in collaboration with all 4TUs and CEE.





7 | Key publications

We distilled a number of 2022-2023 publications that stood out for us, as they represent our strategic agenda and have distinct impact in educational research, teaching practice, and/or education policy.

Many of them come from our PhD candidates, postdoctoral researchers, and project leads/members, but several also come from our CEE leaders and coordinators.

Bohm, N.L., Klaassen, R.G., van Bueren, E. and den Brok, P. (2023), "Education in collaboration with cities: the intentions of transdisciplinary courses", *International Journal of Sustainability in Higher Education*, Vol. ahead-of-print No. ahead-of-print. <https://doi.org/10.1108/IJSHE-11-2022-0359>

In collaboration with their home cities, universities increasingly develop courses in which students investigate urban sustainability challenges. This article aims to understand how far-reaching the collaboration with urban stakeholders in these courses is and what students are meant to learn from the transdisciplinary pedagogies. This research is designed as a qualitative multiple-case study into the intentions of transdisciplinary courses in which universities collaborate with their home cities: Delft University of Technology and Amsterdam Institute for Advanced Metropolitan Solutions. The study compares the written intentions of eight courses in course descriptions with the ideal intentions that teachers describe in interviews.

Bron, R. (2022). *Collaborative course design in higher education: A team learning perspective*. PhD Thesis. University of Twente. <https://doi.org/10.3990/1.9789036554657>

Emerging teaching methods in higher education, such as problem-, and challenge based learning require university teachers to collaborate more when designing and teaching courses. However, the shift towards teamwork can be challenging for them. In this dissertation, the collaborative course design process of university teachers was explored from a team learning perspective. Next to that, the use of sophisticated quantitative analytic techniques in this dissertation added a valuable layer of information to our knowledge of team learning dynamics.

Edstrom, K., Poortmann, C., Magnell, M., & Pereira, P. (2023). Teaching Excellence Programs – Lessons Learned At Two Universities. European Society for Engineering Education (SEFI). <https://doi.org/10.21427/NPKF-KZ96>

Universities are seeking novel ways to strengthen the collective educational competence of their faculty and promote educational merits. This paper describes and compares the experiences of two recently started initiatives for teaching excellence, the Program for Future Leaders for Strategic Educational Development at KTH Royal Institute of Technology and the Teaching Fellowship Programme at the University of Twente.

Van Helden, G., Zandbergen, B. T. C., Specht, M. M., & Gill, E. K. A. (2023). Collaborative Learning in Engineering Design Education: A Systematic Literature Review. *IEEE Transactions on Education*, 66(5), 509-521. <https://doi.org/10.1109/TE.2023.3283609>

This article presents a comprehensive overview of the characteristics of educational designs of collaborative engineering design activities found in literature and how these characteristics mediate students' collaboration. Engineers have to solve complex problems that require collaboration. In education, various collaborative engineering design activities have been implemented to prepare students for these professional practices. According to cultural historical activity theory, educational activities can be described in terms of interrelated elements, i.e., subject, object, tools, rules, division of labor, and community, that influence learning outcomes. A key issue is how these elements mediate students' collaborative efforts and how they contribute to learning.

Grunsven, J., Stone, T. & Marin, L. (2023). Fostering responsible anticipation in engineering ethics education: how a multi-disciplinary enrichment of the responsible innovation framework can help, *European Journal of Engineering Education*, <https://doi.org/10.1080/03043797.2023.2218275>

Engineers must anticipate the socio-ethical impacts of emerging technologies. Such acts of anticipation are thoroughly normative and should be cultivated in engineering ethics education. This paper questions: 'How do we anticipate the socio-ethical implications of emerging technologies responsibly?' And 'how can such responsible anticipation be taught?' The paper offers a conceptual answer, building upon the framework of Responsible Innovation and its four core practices: anticipation, reflexivity, inclusion, and responsiveness.

Van Helden, G., van der Werf, V., Saunders-Smits, G., & Specht, M. M. (2023). The Use of Digital Peer Assessment in Higher Education: An Umbrella Review of Literature. *IEEE Access*, *11*, 22948-22960.
<https://doi.org/10.1109/ACCESS.2023.3252914>

Increasing student numbers in higher education, particularly in engineering and computer science, make it difficult for motivated lecturers to continue engaging in active teaching methods such as Flipped Classrooms and Work Based Learning. In these settings, digital Peer Assessment can be one approach to provide effective and scalable feedback. In Peer Assessment, students assess each other's performance whilst gaining useful reflection and judgment skills at the same time. This umbrella review of 14 review papers on the use of (digital) Peer Assessment in education provides a comprehensive overview of design choices and their consequences open to educational practitioners wishing to implement digital Peer Assessment in their courses, the type of tooling available and the possible effects of these choices on the learning outcomes as well as potential pitfalls and challenges.

Imanbayeva, A., De Graaf, R., & Poortman, C. (2023). Challenge Based Learning In Courses: The Implementation Continuum. European Society for Engineering Education (SEFI).
<https://doi.org/10.21427/X1HC-PZ30>

Given the increasing criticality and complexity of societal challenges, higher education institutions are urged to equip students with the ability to develop sustainable solutions for 'wicked' problems. Consequently, the Challenge Based Learning (CBL) framework has attracted considerable interest in higher engineering education. However, transforming existing course curricula to CBL is a challenging endeavour since it requires careful and paced execution for maintaining the quality, synergy, and flow of existing education. Therefore, this paper proposes a perspective on CBL implementation that exemplifies a gradual transition towards educational CBL innovation while reflecting on the alignment, consistency, and coherence educators aspire to when designing courses.

Hermesen, P. E. A., Rooij, R. M., Rijnbeek, G., & Adrichem, T. (2022). Reflection in Engineering Education: White paper '100 Days of... Reflection'. Delft University of Technology.
<https://research.tudelft.nl/en/publications/reflection-in-engineering-education-white-paper-100-days-of-refle>

Reflection is a term often heard and refers to a process in which people make sense of and interpret a specific experience to yield insight into where they stand and how to go on. But what is meant by it in the context of engineering education? How do we see reflection being applied in engineering, and where? To what could it contribute? And what are the challenges involved?

In 100 days, 'Reflection in Engineering Education' has been explored through journal clubs, conversations, presentations, a case pitching workshop, and peer exchange among scientific staff and educational support. This paper outlines this exploration to make reflection more accessible and concrete within the context of TU Delft Engineering Education.

Klaassen, R. G., Hellendoorn, J., & Bossen, R. H. (Accepted/In press). Transforming Engineering Education in Learning Ecosystems for Resilient Engineers. *IEEE Transactions on Education*, 1-12. <https://doi.org/10.1109/TE.2023.3303364>

The TU Delft education system is transformed on several levels: new courses and projects in existing BSc and MSc programmes for multi-disciplinary and reflective learning; new MSc programmes focusing on multi- and interdisciplinarity, personal development, and professional skills; and central Interdisciplinary Projects for Master Students from different programmes. With these steps, the university offers students a learning ecosystem where identity-building can occur, interdisciplinary teamwork is fostered, and strong interaction with the professional world and government is stimulated. In this article, the ecosystem is explained, and experiences from students are shared. The survey results show that students understand their future role in the community as engineers, feel that they have acquired new skills, feel better about framing complex problems, and are more competent to work in the industry.

Puffelen, E. van, Stevens, T., Banihashem, S. K., Biemans, H., Noroozi, O., Raeven, N., & Brok, P. den (2022). Covid-19 forced remote teaching and university education after it. *Proceedings of the 18th International CDIO conference*, June 13-15, 2022, Reykjavik, University of Reykjavik. <http://www.cdio.org/content/proceedings-18th-international-cdio-conference>

The COVID-19 outbreak at the beginning of 2020 disrupted students' and teachers' learning and teaching activities worldwide as it led to a quick transition from education, including face-to-face interaction to emergency remote teaching. During this period monitoring research on the experiences and innovation needs was done at Wageningen.

The results show that a focus on student well-being is needed in the years ahead. Students indicated a lack of sense of connectedness and a strong desire to have face-to-face education. For the following years, online versions of most courses should be available to stay prepared for online education when needed.

Rooij, R. M., Walsarie Wolff, C. S. F., & den Brok, P. (2023). *Room for everyone's educational talents. Six recommendations for (more) visible succes in the workplace in recognizing and rewarding university teaching, teaching quality, and educational career paths within the 4TUs.* 4TU Centre for Engineering Education. <https://www.4tu.nl/cee/Publications/230829-english-advice-4tu-room-for-everyones-educational-talents.pdf>

The rectors requested the 4TU.Centre for Engineering Education to recommend a strategy on how to accelerate the closing of the gap between policy and practice focusing on recognizing and rewarding university teaching, teaching achievements, and teaching quality. The advice report presents six recommendations supported by many concrete possible actions, directed at various stakeholders: university teachers, their supervisors, academic leaders, HR managers, and career development committees.

Rooij, R. M. (Ed.), Mooij, S. C. (Ed.), & Wilmink, C. L. (2022). *Gezond Uitdagend Ontwerponderwijs: Ervaringen vanuit TU Delft: Bouwkunde en Industrieel Ontwerpen*. 4TU.Centre for Engineering Education. <https://www.4tu.nl/cee/innovation/project/13161/study-stress-in-design-education>

This book presents three models, three ways of looking at healthy challenging design education, and also a large set of experiences in the format of short stories written by Delft design students, design teachers, and study advisors. The models are applied to those stories and show how students and teachers could more or less constructively go forward in stressful situations in learning and teaching design. This book is used by and distributed among all our Delft bachelor design students and teachers.

Stevens, T.M., Day, I.N.D., Brok, P. den, Prins, F. J., Assen, H.J.H.E, Beek, M. ter, Bombaerts, G., Coppoolse, R., Cremers, P.H.M., Engbers, R., Hulsen, M., Kamp, R.J.A., Koksma, J.J., Mittendorff, K., Riezebos, J., Rijst, R.M. van der, Wiel, M.W.J. van de, & Vermunt, J.D. (in press). Teacher Professional Learning and Development in the context of Educational Innovations in Higher Education: A Typology of Practices. Published online in *Higher Education Research and Development*. <https://doi.org/10.1080/07294360.2023.2246412>

This article compares and analyses 32 cases in which academic universities and universities of applied science were involved in educational innovation and in which teacher learning was visible. Different characteristics of innovations, teacher support and different learning outcomes were mapped. Three different constellations were found in which educational innovation, teacher support and learning activities and outcomes were related. Each of these constellations is analyzed more in-depth.

Tassone, V., Tho, C., Brok, P. den, & Wals, A. (2022). Cultivating students' sustainability-oriented learning at the interface of science and society: A configuration of interrelated enablers. *International Journal of Sustainability in Higher Education*, 23 (8), 255-271. <http://dx.doi.org/10.1108/IJSHE-01-2022-0014>

This article investigates different constellations of factors that enable successful learning of students and other actors in the context of a university-wide course in which students collaborate in interdisciplinary teams to find solutions to real-life problems of societal actors. It contributes to our understanding of how to best organise and support the organisation of complex challenge based courses.

Vonk-Franke, C. A., Ventura-Medina, E., Snijders, C. C. P., Matzat, U., Zhang, R., & Cristea, T. (2023). Integrating Learning Analytics into Engineering Education: Design Strategies for Teachers. In G. Reilly, M. Murphy, B. V. Nagy, & H.-M. Jarvinen (editors), SEFI 2023 - 51st Annual Conference of the European Society for Engineering Education: Engineering Education for Sustainability, Proceedings (blz. 3278-3283). European Society for Engineering Education (SEFI). <https://doi.org/10.21427/81EY-XH76>

While reflecting on the role of engineering education for a sustainable world, one must consider one of the most important game-changers in education of this century: the use of big data, and within it, Learning Analytics (LA). This workshop provides an opportunity for engineering educators to learn about LA, how it can be incorporated in their course design and what LA literacy do teachers and students need to take advantage of this approach.

Vreekamp, M., Runhaar, P., Gulikers, J., & Brok, P. den (in press). A systematic review to explore how characteristics of pedagogical development programmes in higher education are related to teacher development. Accepted for publication to *International Journal for Academic Development*. <https://www.tandfonline.com/doi/full/10.1080/1360144X.2023.2233471>

This article presents the result of a comprehensive literature review on professional development programmes (such as the University Teaching Qualification trajectories), by investigating characteristics of these trajectories, learning activities organised, and learning outcomes of teachers involved in the programmes. The article finds several characteristics that positively contribute to a variety of learning outcomes.

Zhang, X., & Specht, M. M. (2022). A Review of Reviews on Computational Thinking Assessment in Higher Education. In *Proceedings of Sixth APSCE International Conference on Computational Thinking and STEM Education 2022 (CTE-STEM)* (pp. 98-103) <https://doi.org/10.34641/ctestem.2022.472>

There is an urgent need for educating the next generation of learners with digital tools and making use of digital practices and skills. However, most of the work on computational thinking in higher education has been focused on teaching and learning programming while less attention has been paid to the underlying skills and competences. In this article 11 reviews were analyzed to identify constructs being assessed, methods and their characteristics for the delivery of assessment, and the context in which the assessment was conducted. The findings indicate that there is certain consensus in the field on what constructs to measure. Last but not least, it was determined from this study that there are often no standards or principles followed for the design of assessment.



INTERMEZZO

ChatGPT

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In response to the sudden raise of ChatGPT in 2022/2023, WUR researchers conducted a SWOT analysis on its use. This [journal article](#) presents the SWOT framework - Strengths, Weaknesses, Opportunities and Threats - to review existing and upcoming literature to identify the threats, but also the opportunities for using ChatGPT in university education.

As these kinds of tools will be here to stay, this article offers input for the 4TU to make proper use of them and also develop supporting policies and guidelines for their usage. Moreover, practical guidelines and supporting structures developed in the Netherlands and abroad are identified and collected. All these inputs are used to develop concrete guidelines and handles for making use of AI in assessment practices and advise teachers and the Board of Examination in how to go about these practices.



8 | Keynotes and media appearances

We distilled a selected number of 2022-2023 keynotes and media appearances of our CEE leaders which stood out for us, as they represent our strategic agenda and have distinct impact in educational research, teaching practice, and/or education policy.

Brok, P. den & Poortman, C. (2023). *Stimulating sustainable implementation of educational innovation in engineering education.*

Joint keynote at the SEFI European Convention for Deans, May 24-26, Enschede, University of Twente.

Brok, P. den (2022). *Onderwijsinnovatie en design-based onderwijs.* Keynote for the inauguration as lector Design Based Education, Migchiel van Diggelen, Leeuwarden, 14 April 2022.

Brok, P. den (2022). *University teaching during the Covid-19 period: reports from a longitudinal monitoring study.* Keynote presented at the MIER (Model Institute for Education and Research) International Conference 2022: Perspectives in teaching, learning and assessment during the Covid-19 pandemic. Jammu, India, 19 May 2022.

Brok, P. and Rooij, R. (2023). *Dubbelinterview* voorzitter Remon Rooij & oud-voorzitter Perry den Brok. 4TU.Federation.

Poortman, C. (2023). Main organiser SEFI European Convention for Deans, May 24-26, Enschede, University of Twente, with all 4TU. CEE-leaders.

Rooij, R. (2023). *Teaching culture, evidencing teaching achievements, and academic careers.* Invited speaker at the 'Landelijke techniek-decanendag'. Eindhoven, TU Eindhoven, 31 August 2023.

Rooij, R. (2023). *Healthy Challenging Design Education – the balance between learning and performance.* Architecture and the Built Environment Research Stories. TU Delft.

Specht, M. (2022). *Learning Engineering and Educational Innovation Research.* Keynote given at the Tag der Lehre, Leibniz University Hannover, Germany. 17 February 2022.

Specht, M. (2023). *A vision on digital engineering education and propositions for leadership.* Keynote given at the European Convention of Engineering Deans, University of Twente, Netherlands. 25 May 2023.

Ventura-Medina, E. (2023). *Education innovation: engineer of the future.* Invited speaker at the 'Landelijke techniekdecanendag'. Eindhoven, TU Eindhoven, 31 August 2023.

Ventura-Medina, E. (2023). SEFI deans panellist at the SEFI European Convention for Deans. May 24-26, Enschede, University of Twente.

PROFESSIONAL DEVELOPMENT

Photo: Bart van Overbeek, Fotografie, TU Eindhoven



9 | Overview postdoctoral researchers, PhD candidates, MSc students

Postdoctoral researchers

in order of end dates

Nauman Ahmed (TUD) - *Libket project (2020-2022)*. Supervision team: Dr Matthias Moller.

Nathalie van der Wal (TUD) - *PRIME Project and Math Education: self-directed learning in blended education and transferable skills in engineering curricula (2020-2022)*. Supervision team: Prof. Annoesjka Cabo, Prof. Geurt Jongbloed.

Jacqueline Wong (TUD) - *PRIME Project and Math Education: self-directed learning in blended education and transferable skills in engineering curricula (2020-2022)*. Supervision team: Prof. Annoesjka Cabo, Prof. Geurt Jongbloed.

Canan Mesutoglu (TU/e) - *Deepening multidisciplinary within signals & control, daily supervisor Dury Bayram-Jacobs and c-mode-up implementation (2021-2022)*. Supervision team: Ines Lopez Arteaga.

Ulises Salinas-Hernandez (TU/e) - *Student Learning experiences in Challenge-based education: the cases of applied mathematics and physics (2021-2023)*. Supervision team: prof. Birgit Pepin.

Zeger-Jan Kock (TU/e) - *Student Learning experiences in Challenge-based education: the cases of applied mathematics and physics (2021-2023)*. Supervision team: prof. Birgit Pepin.

Tahir Abbas (TUD) - *Uncage Project (2021-2023)*. Supervision team: Dr Ujwal Gadiraju (TUD).

Ufuk Gür (TUD - UT) *Entrepreneurial Engineering Education – Train-the-Trainer*. End date: 2025. Supervision team: Prof. Frido Smulders (TUD), Dr Rainer Harms (UT), Dr Raymond Loohuis (UT).

Zahar Koretsky (TU/e) *Transformative education for sustainability at TU/e*. End date: 2025. Supervision team: Prof. Anna Wiczorek and Prof. Isabelle Reymen.

Alaa Abdalla (TU/e) *Learning together in CBL*. End date: 2025. Supervision team: Dr Gunther Bombaerts.

PhD candidates

in order of expected end dates

Nina Bohm (TUD) - *Living Labs in Engineering Education*. Expected end date: 2024. Supervision team: Prof. Ellen van Bueren, Prof. Perry den Brok (WUR), Dr Renate Klaassen.

Ljubov van Beek (TUD) - *Self-directed learning in Higher Education*. Expected end date: 2024. Supervision team: Prof. Marc de Vries, Dr Maartje van den Bogaard.

Priyanka Pereira (UT) - *Peer feedback in higher education*. Expected end date: 2024. Supervision team: Prof. Kim Schildkamp, Prof. Bernard Veldkamp, Dr Maaïke Heitink.

Marta Gavioli (TUD) - *Hands-on Learning in Structural Mechanics*. Expected end date: 2024/2025. Supervision team: Prof. Annoesjka Cabo, Prof. Chiara Bisagni, Prof. Perry den Brok, Dr Renate Klaassen.

Xin Ming (UT) - *Interdisciplinarity in action - Configuring and constructing interdisciplinary engineering education*. Expected end date: 2024/2025. Supervision team: Prof. Mieke Boon, Dr Miles MacLeod, Prof. Jan van der Veen.

Kishore Sivakumar (UT) - *Promoting higher order thinking skills in engineering education for interdisciplinary research*. Expected end date: 2025. Supervision team: Prof. Mieke Boon, Dr Miles MacLeod.

Marloes Vreekamp (WUR) - *Teacher learning during the University Teaching Qualification trajectory*. Expected end date: 2025. Supervision team: Prof. Perry den Brok, Dr Judith Gulikers, Dr Piety Runhaar.

Gitte van Helden (TUD) - *The development of collaborative design labs for educational purposes*. Expected end date: 2025. Supervision team: Prof. Eberhard Gill, Prof. Marcus Specht, Barry Zandbergen.

Thijs Loonstra (WUR) - *Ethics and sustainability in engineering education*. Expected end date: 2026. Supervision team: Prof. Perry den Brok, Dr Valentina Tassone, Dr Zoë Robaey.

Victor Garcia Galofré - (TU/e – WUR) *Entrepreneurial learning and entrepreneurship in engineering education*. Expected end date: 2026. Supervision team: Prof. Isabel Reymen (TU/e), Prof. Perry den Brok (WUR), Dr Duygyu Keskin (TU/e), Dr Yvette Baggen (WUR).

Linlin Pei (UT) - *An effective professional development model for higher education institutions - Support for instructors on blended learning development*. Expected end date: 2026. Supervision team: Prof. Kim Schildkamp, Prof. Nieck Benes, Dr Cindy L. Poortman.

Erna Engelbrecht (TUD) - *Evaluating of innovations in engineering education*. Expected end date: 2027. Supervision team: Prof. Marcus Specht, Dr Remon Rooij, Prof. Johannes Strobel.

MSc students

Sarah de Vries (WUR) - *Mixed Classroom*.
Expected end date: 2027. Supervision team:
Prof. Perry den Brok, Dr Judith Gulikers.

Adina Imanbayeva (UT) - *The development of teacher competencies for educational innovation in facilitating learner empowerment*. Expected end date: 2028. Supervision team: Prof. Klaasjan Visscher, Dr Cindy L. Poortman, Dr Marcus Pereira Pessoa, Dr Robin de Graaf.

Ran Zang (TU/e) - *Click2Empower*. Supervision team: Prof. Chris Snijders, Dr Uwe Matzat.

Caroline Vonk (TU/e). *Education4Sustainability*.
Supervision team: Prof. Esther Ventura-Medina,
Dr Valentina Tassone (WUR).

Laura Menschaart (TUD) *Emotion regulation in online Math (service) Education*. Supervision team: Prof. Annoesjka Cabo, Dr Martine Baars.

Adina Imanbayeva (2022, UT) *Challenge based learning for fostering students' sense of impact*.
Supervision team: Dr Cindy L. Poortman,
Dr Robin de Graaf.

Preeti Mishra (2023, UT) *Challenge Based Learning to Achieve Higher-order Thinking Skills*.
Supervision team: Dr Cindy L. Poortman, Dr Robin de Graaf.

Levi Baruch (2023, TU/e). *Embracing the future: the use of ChatGPT in Science Teacher Education*.
Supervision team: Dr Lesley Putter PdEng.



INTERMEZZO

PhD networks

International exchange and working with peers in engineering education research is essential for advancement, quality assurance and knowledge sharing of research methods and results. 4TU.CEE co-organises several initiatives especially targeted for researchers in engineering education and brings together PhD candidates, senior researchers and lecturers interested in research on engineering education.

Since 2021, 4TU.CEE, Leuven Engineering & Science Education Centre at KU Leuven and Teaching & Learning Lab in Engineering and IT at the University of Melbourne organise the PRACtESE Symposia (PhD Research Across CONtinents in Engineering and Science Education). In PRACtESE the community organises online symposiums for sharing current research and PhD projects and discusses present-day topics in an international community of engineering education researchers.

Extending on initiatives of graduate school programmes, PhD summer schools are an essential component of the regular exchanges on contemporary topics of engineering education. The European Society for Engineering Education organises a regular summer school for PhD candidates to which 4TU.CEE contributes with workshops and presentations.

In addition, the European Association for Technology Enhanced Learning organises a summer school for PhDs in ICT enhanced learning to which 4TU.CEE regularly contributes; by sharing challenges, approaches, methods and results with peers in the field.

Colophon

Midterm Progress Report 4TU.CEE 2022-2023

Engineer of the Future and Future of Engineering Education
4TU Centre for Engineering Education

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